CCME

Canadian Council of Ministers of the Environment

Le Conseil canadien des ministres de l'environnement

NATIONAL ACTION STRATEGY

ON

GLOBAL WARMING

November, 1990

PREFACE

Canada's National Action Strategy on Global Warming was prepared under the auspices of parallel steering committees of Environment and Energy Deputy Ministers. The paper proposes a strategic framework for actions to be undertaken jointly by governments and all other sectors of the economy to combat global warming. Within this strategic framework, governments, in consultation with stakeholders, will develop and implement specific measures within their jurisdictions.

The proposed National Action Strategy on Global Warming was considered by the Canadian Council of Ministers of the Environment (CCME) at their annual meeting held in Victoria in November 1990. At that time, Ministers agreed to make the paper available for public consideration. Environment Ministers have also referred it formally to Energy Ministers for their consideration.

Environment Ministers plan to consider comments on the National Action Strategy at their meetings in May and November 1991.

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RECOMMENDATIONS FOR NATIONAL ACTION STRATEGY

Canada's Environment and Energy Ministers have recognized climate change as an issue that needs to be addressed. At their meeting during Globe '90 in March, Environment Ministers instructed a steering committee of environment deputies to develop a comprehensive national action strategy on global warming, in cooperation with energy deputies and other sectoral ministries. At their meeting in Kananaskis in April, Energy Ministers endorsed the need for joint action. This paper proposes a strategic framework for a national action strategy to be undertaken jointly by government and all other sectors of the economy in the context of the current state of scientific knowledge about the issue of global warming. Within this strategic framework, governments, in consultation with stakeholders, will be developing and implementing specific measures within their jurisdictions.

The principal recommendations of the paper are as follows.

1. Canada's national action strategy on global warming should have three components

   - limiting greenhouse gas emissions
   - anticipating and preparing for potential climatic changes which Canada may experience as a result of global warming, and
   - improving scientific understanding and increasing predictive capability with respect to climate change.

2. The limitation component of the strategy should have four principles

   - it should be comprehensive, addressing all greenhouse gases and sinks, and taking account of interactions with other atmospheric issues and pollutants
   - it should recognize the importance of the international context - Canada has a responsibility to take action to address global warming based on internationally agreed targets and schedules, while recognizing that taking certain actions out of step with other nations would have little impact and could jeopardize our competitive position internationally
   - it should be flexible, adaptable over time to new information and developments, and

- it should recognize the importance of regional differences.

3. Reflecting these principles, the limitation strategy should have the following elements

   - broad consultations involving all sectors - all Canadians have a responsibility and a role in reducing greenhouse gas emissions

   - continued work towards an international convention and protocols on reducing greenhouse gas emissions

   - targets and schedules for reducing greenhouse gas emissions, and

   - a phased, progressive approach towards limiting emissions that is implemented after adequate assessment of the implications and effectiveness of measures.

4. In keeping with Canada's commitment, first made at the May 1990 UN conference in Bergen and reaffirmed at the November Second World Climate Conference in Geneva, the first step towards limiting emissions should be the stabilization of "emissions of carbon dioxide and other greenhouse gases not controlled by th Montreal Protocol" at 1990 levels by 2000. This is a national target and does not pertain to specific regions or sectors. More ambitious targets will be considered as the remaining scientific uncertainties surrounding the problem of climate change are better understood, but only in the context of a program of targets and schedules agreed upon internationally.

5. The federal, provincial and territorial governments should develop and implement measures to deal with greenhouse gas emissions in consultation with all stakeholders. As a first step, measures which make sense in their own right should be implemented. Some of these measures would promote activities which are economic in terms of energy savings or some other economic benefit, for example energy efficiency/conservation improvements and the use of alternative energy. Some energy efficiency/conservation measures would also reduce other atmospheric emissions, and reduce our reliance on imported fuel. Some first step measures would also help to achieve other environmental policy objectives, as in the case of phasing out chlorofluorocarbons (CFCs) and controlling NO_x and VOC emissions. While many of the activities promoted would be economic, government action is required to provide information on the availability and benefits of measures, and to overcome market barriers. In evaluating the

measures, full consideration should be given to the costs to governments and other sectors. The success of measures implemented to reduce emissions should be carefully monitored through a detailed inventory and reporting system of greenhouse gas sources and sinks.

6. The federal, provincial and territorial governments should commence examination of longer lead time and more far-reaching measures that may become necessary to reduce greenhouse gas emissions. These examinations should include an assessment of the costs and benefits and the social implications of the measures. The examinations should address tax and further incentive strategies for reducing greenhouse gas emissions, electricity pricing structures, the incentives provided by electric and gas utility regulatory structures for more efficient electricity and gas use/conservation as compared to supply expansion, electricity generation options (including so-called clean coal technologies), lifestyle changes, and changes in the way our cities function.

7. The principles and elements of the national action strategy should be codified in federal/provincial agreements. The agreements should specify the actions the federal and provincial governments will take to limit emissions of greenhouse gases, to anticipate and prepare for potential climate change, and to improve scientific understanding. The agreements should also establish the institutional arrangements that will be used to manage implementation of the agreements, the means and schedule for publicly reporting progress, and the manner in which the specific obligations in the agreements can be amended. It is proposed that the specific obligations in the agreements initially be limited to the early actions governments decide to take. These agreements should be subsequently amended to reflect more comprehensive measures as they are developed through consultation processes with all interested parties. The agreements should be further amended to include other actions necessary to achieve the emission reductions identified in international agreements.

8. The federal, provincial and territorial governments and other appropriate agencies should take action to improve the scientific understanding of climate change, and to assist adaptation to potential climatic changes which Canada may experience as a result of global warming.

9. This report on the national action strategy should be made public. The strategy should be systematically updated, and subsequent reports also made public.

NATIONAL ACTION STRATEGY ON GLOBAL WARMING

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CHAPTER 1: INTRODUCTION

Over the past decade, the world has been increasingly alerted to the fact that the changing composition of the atmosphere will lead to change in the global climatic system. There is a concern that man-made emissions of the so-called greenhouse gases will lead to a major warming of the earth's surface.

The issue of global warming is being addressed in a number of fora. Internationally, the work of the Intergovernmental Panel on Climate Change (IPCC) has been the principal focus of activity. The report of the IPCC was submitted to governments at the Second World Climate Conference in Geneva at the end of October.

The issue is also being addressed domestically. In August, 1988, federal, provincial and territorial energy ministers established a task force to review the energy recommendations of the Toronto Conference on the Changing Atmosphere. The Task Force on Energy and the Environment issued two reports, in August, 1989, and April, 1990. The House of Commons Standing Committee on the Environment held special hearings on global warming in 1989/90, at which a large number of expert witnesses testified. The issue of global warming figured prominently in the cross-country consultations that were held this spring on the federal government's *Green Plan*, as well as in a number of ongoing provincial consultation processes.

At their meeting in March, 1990, Canadian Environment Ministers addressed the issue of global warming. Ministers recognized their responsibilities in assuming a leadership role in developing a comprehensive national action strategy, and instructed a steering committee of environment deputies to develop the strategy, in cooperation with energy deputies and other sectoral ministries. This paper has been prepared in response to Ministers' instructions. It outlines a strategic framework for addressing the problem of global warming. Measures to be introduced by various levels of government to implement elements of the strategy will be announced independently. It is intended that the strategy be updated periodically to take account of the effectiveness of the measures introduced by governments, and that this report and the updates be made public.

It is proposed that the principles and elements of the national action strategy be codified in federal/provincial agreements. The agreements should specify the actions the federal and provincial governments will take to implement the strategy. The agreements should also establish the institutional arrangements that will be used to manage implementation of the agreements, the means and schedule for publicly reporting progress, and the manner in which the specific obligations in the agreements can be amended. It is proposed that the specific obligations in the agreements initially be limited to the early actions governments decide to take, and that the agreements be

systematically updated to include the more comprehensive measures which will be developed over time.

CHAPTER 2: NATURE OF PROBLEM

2.1 SCIENTIFIC EVIDENCE

Throughout the 1980s, there developed an increasing awareness among scientists and policy makers of the fact that the changing composition of the atmosphere will lead to change in the global climatic system. This awareness led to the establishment of the Intergovernmental Panel on Climate Change (IPCC) in 1988 under the auspices of the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP). In Canada, the Canadian Climate Program Board (CCPB) has prepared a statement for CCME which reviews the work of the IPCC, with a particular focus on the potential implications of climate change for Canada.

The CCPB notes that many years of scientific measurements at observing stations in Canada and around the world indicate unequivocally that the atmospheric concentrations of the "greenhouse gases" (carbon dioxide, methane, the chlorofluorocarbons (CFCs), nitrous oxide and ground-level ozone) are increasing rapidly. Carbon dioxide and methane concentrations in the global atmosphere have reached their highest values in more than 160,000 years. The rising concentrations, which are largely due to human activities such as the burning of fossil fuels, various industrial processes, and changing land uses, are enhancing a natural greenhouse effect, resulting in additional warming of the earth's surface. Some of these gases - carbon dioxide, CFCs and nitrous oxide - are only slowly removed from the atmosphere; following a change in emissions, their atmospheric concentrations would take decades to centuries to adjust fully.

The CCPB goes on to note that, if no response measures are taken, greenhouse gas emissions from most sources will continue to increase significantly. Under the IPCC's Scenario A, which assumes that few or no steps are taken to limit emissions, it is estimated that CO_2 emissions, which account for over 50 per cent of the anthropogenic greenhouse gas effect, will increase from approximately 7 billion tonnes of carbon in 1985 to between 11 and 15 billion tonnes by the year 2025. Other greenhouse gas concentrations will also rapidly increase, except for CFCs, which will be reduced under the Montreal Protocol. With reductions in CFCs, the energy sector will contribute some two-thirds of the human-induced greenhouse effect over the period 2000 to 2025.

Based on these projections and results from the best mathematical models used to simulate the earth's climate system, the IPCC has predicted an increase of global mean temperature above pre-industrial levels of more than 2°C by 2050 and 4°C before the end of the next century. These are rates of change unprecedented in recorded history, and, according to the IPCC,

will be accompanied by sea level rises which would be catastrophic for some low lying countries.

Climate changes over Canada will be different from the global mean. Warming is expected to be significantly greater in Canada's Arctic during winter; and greater than average temperature increases in Central North America are predicted to be accompanied by reduced summer soil moisture. Since climate is naturally variable from year to year, the temperature rise will not be steady. While models agree reasonably well on global and large scale features, limitations, involving spatial resolution and incomplete simulation of some processes (clouds, sea ice, hydrologic cycle and oceans) result in less confidence at a smaller regional and local scale.

The CCPB lists a number of impacts of potential climate change under the IPCC's Scenario A with particular significance for Canada, including the following:

- shift of climatic zones several hundred kilometres northward over the next 50 years; flora and fauna would lag behind these climatic shifts, and the rate of climate change may be too fast for some species to survive.

- potential for northward expansion of agricultural crops where soils permit, up to the southern boundary of the Canadian Shield;

- increased drought risks, especially in the Prairies;

- shift northwards of forest ecosystems but with narrower boundaries for some species; increased fire, insect and disease attacks are probable;

- large changes in water resources; potential decrease in net basin run-off of 25 to 50 per cent in the Great Lakes-St. Lawrence system; lower summer soil moisture in the Prairie provinces, and larger flood flows in northern rivers;

- adverse effects on human health associated with more frequent and intense heat waves in cities, and the poleward spread of tropical diseases;

- significant degradation of permafrost within the next 40-50 years; overlying ecosystems and wildlife habitat could be significantly altered affecting northern indigenous people; structures such as pipelines and buildings would be seriously threatened;

- acceleration of sea-level rise and modification of ocean temperatures and circulation; sea-level rise would increase shore erosion, change coastal ecology, affect wetlands and important fisheries and necessitate significant costs for coastal protection; ocean changes will impact on fish distribution and migration routes.

2.2 CANADA'S CONTRIBUTION TO PROBLEM

Consistent and reliable data on emissions of all of the greenhouse gases, whether nationally or internationally, are not available. The most reliable data are available for emissions of carbon dioxide, although even estimates of carbon dioxide emissions from certain sectors, such as agriculture, are uncertain. Data on emissions of methane and nitrous oxide, in particular, are less reliable than data on emissions of carbon dioxide.

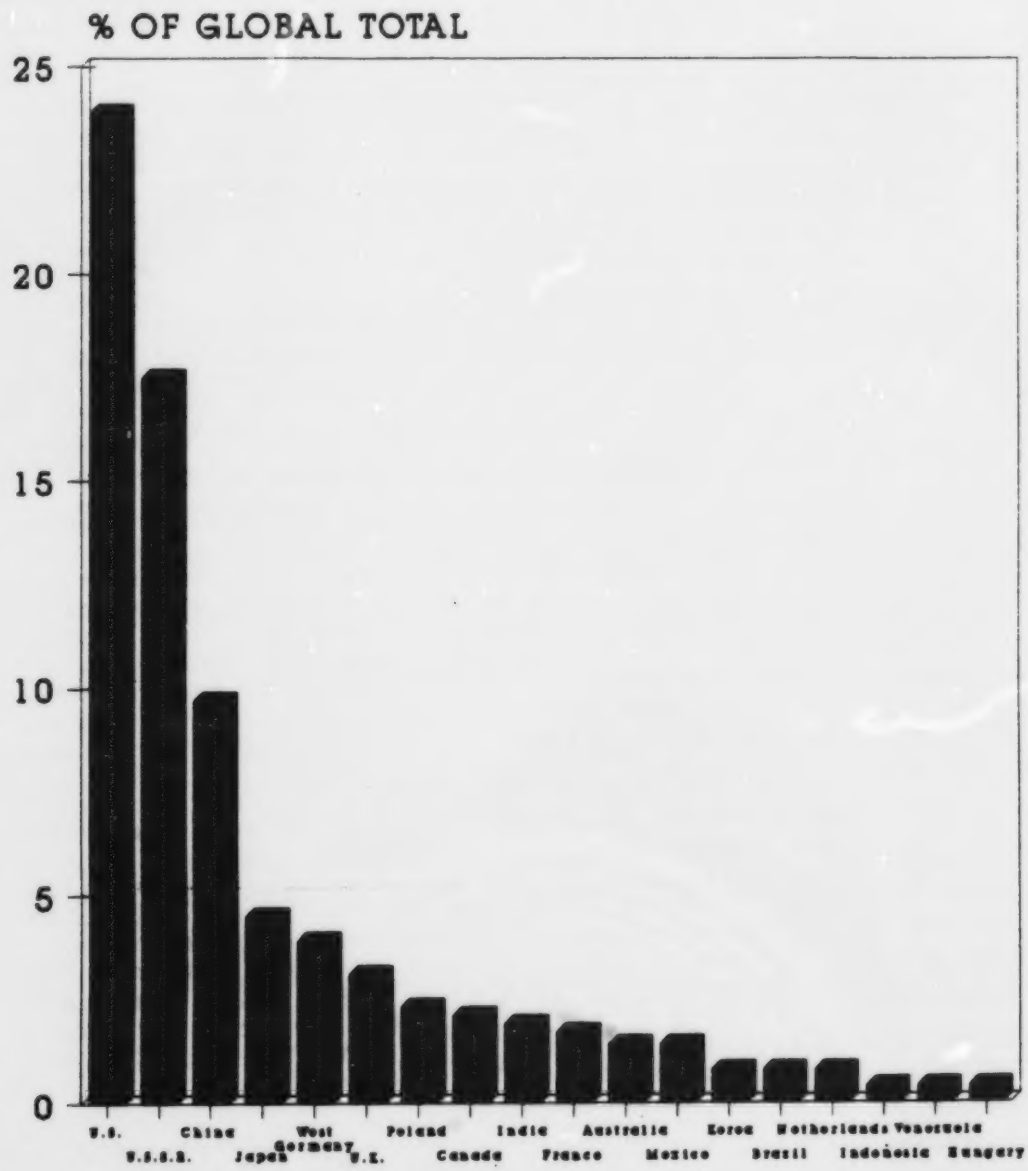
Work is on-going to obtain better data in all of these areas. In the meantime, preliminary, but the best available data, has been compiled by Environment Canada and Energy, Mines and Resources Canada on Canadian anthropogenic emissions of the four principal greenhouse gases for a base year (1987 - more recent data are available for carbon dioxide). Expressed in terms of CO_2 equivalents, which takes account of global warming potential, these data indicate that CO_2 accounted for about 66 per cent of Canada's known man-made greenhouse gas emissions in 1987, CFCs 17 per cent, methane 12 per cent, and nitrous oxide 5 per cent. Estimates for the contribution of ground-level ozone are not available. As the IPCC has noted, the contribution of ground-level ozone to global warming may be significant but is difficult to quantify.

Energy consumption and agricultural land use are the two principal man-made sources of CO_2 emissions in Canada. A preliminary estimate of emissions from agricultural land use is that these amount to approximately 85 million tonnes of CO_2 per year; this estimate, however, is highly uncertain. Fossil-fuel energy use accounts for over 450 million tonnes of CO_2, approximately 5 times the estimated contribution of agriculture. Non-energy sources other than agriculture, such as cement and ammonia production and incineration, account for about 12 million tonnes per year.

Figure 1 indicates the relative contribution of a number of countries to global energy-related CO_2 emissions. Canada is clearly only a very small part of the global picture, accounting for about 2 per cent of world emissions. Preliminary estimates indicate that Canadian emissions of methane and nitrous oxide represent roughly between 1 and 2 per cent of world totals. Our share of world CFC emissions is also about 2 per cent. Canada alone, therefore, can have no meaningful impact on reducing world greenhouse gas emissions. We clearly will have to work at the international level to help resolve the problem of global warming.

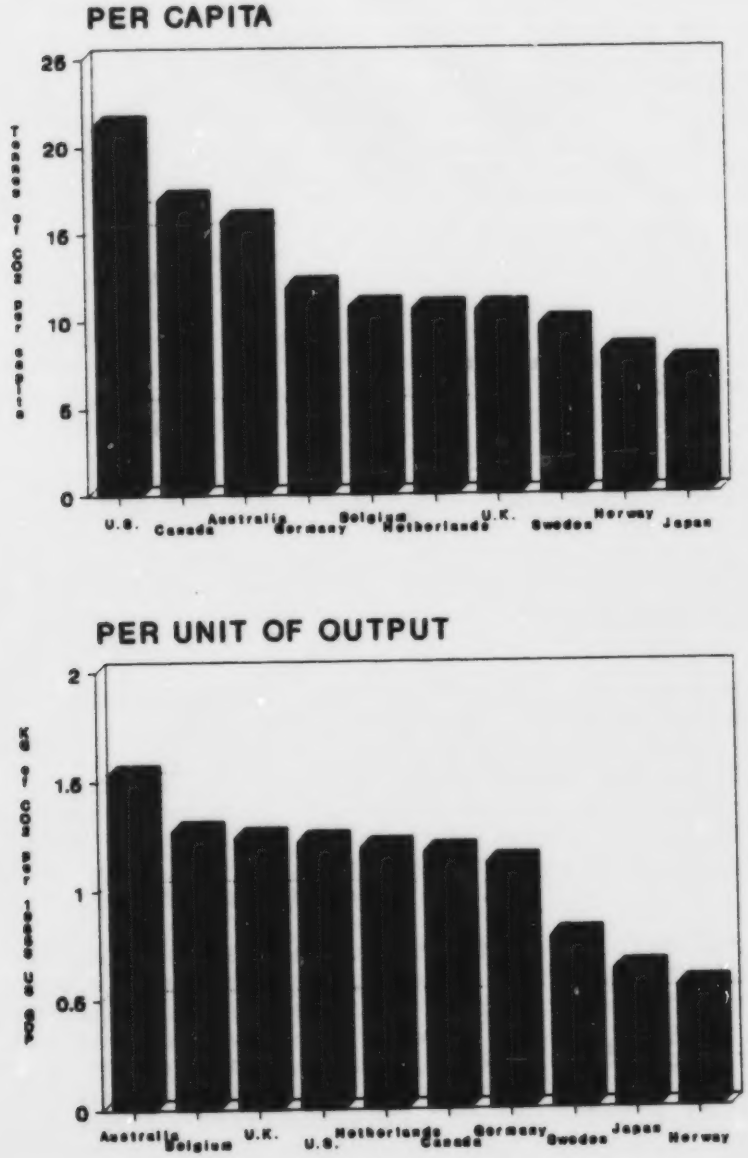
While Canada accounts for only a very small part of total world emissions of greenhouse gases, we rank high among industrialized countries in terms of energy-related carbon dioxide emissions when measured on a per unit of population or per unit of national income basis. Canada is second among industrialized countries in terms of energy CO_2 emissions per

Figure 1
ENERGY CO_2 EMISSIONS (1985)



Source: IPCC, EIS Subgroup

Figure 2
COMPARATIVE ENERGY CO_2 EMISSIONS INTENSITIES - 1987



Source: IEA

capita, and sixth in terms of emissions per unit of GDP (Figure 2). This is largely due to factors such as climate, population density, and our resource extraction-based economy (more details on Canada's emissions of CO_2 and other greenhouse gases can be found in Annex 1). It is also worth noting that because of Canada's energy mix, we emit considerably less CO_2 per unit of energy consumed than many other countries. There is, however, evidence that there is significant scope for actions to reduce emissions - for example, through improvements in the efficiency with which we use energy - which are economic or which also assist in achieving other policy objectives. By realizing these opportunities, we can begin to act on our responsibility as an industrialized country in responding to the problem of global warming, and at the same time serve our economic interests.

CHAPTER 3: THE INTERNATIONAL CHALLENGE

Canada is participating with its international partners in seeking a coordinated approach to global warming. The issues involved in reaching an international agreement are similar to those encountered in addressing other environmental problems such as ozone depletion. These issues include the need to improve scientific understanding, the global nature of the problem - no single country can resolve it - the need to involve developing countries, and the linkages to international trade.

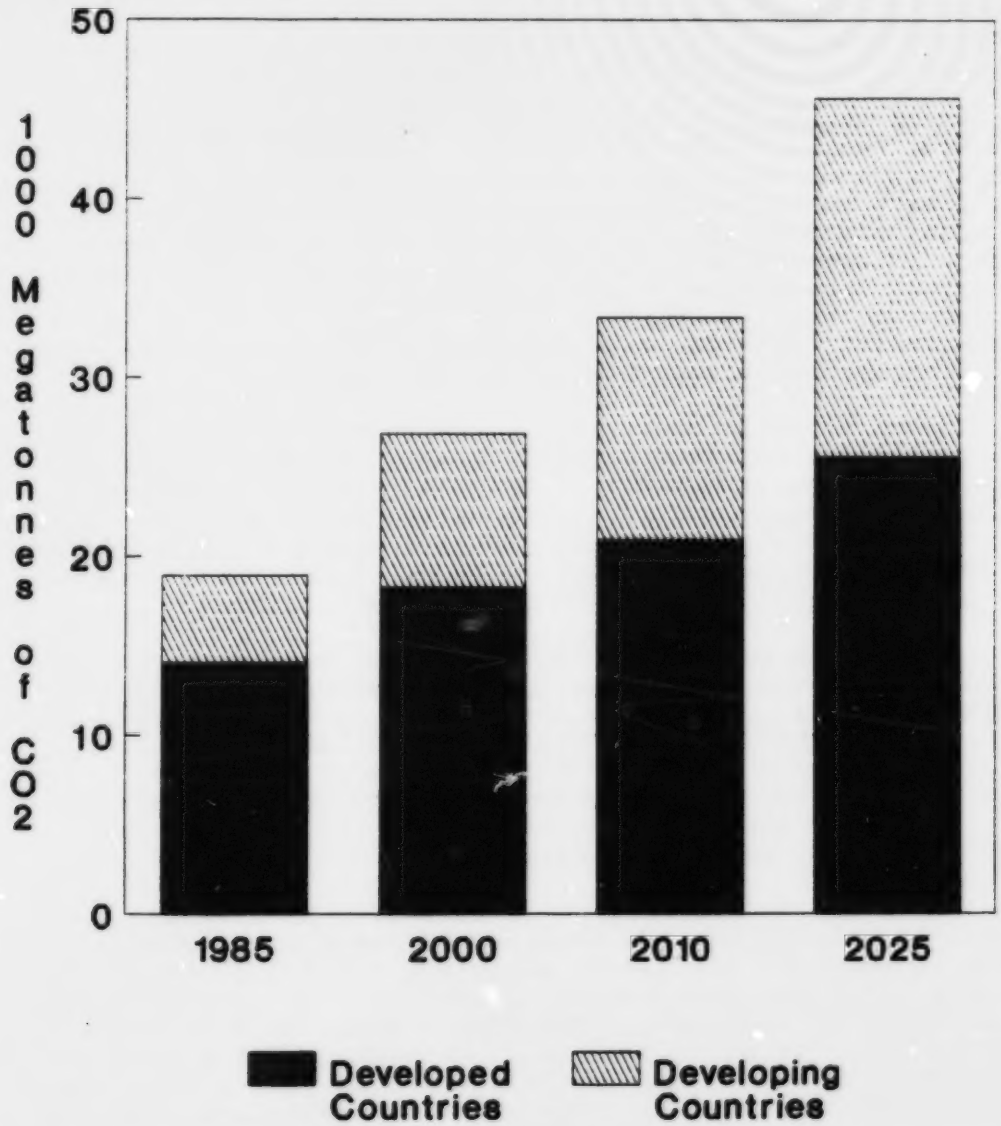
While there are similarities between the issues involved in reaching international agreement on a coordinated approach to global warming and other environmental problems, the difficulties are likely to be more severe in the case of global warming. This is because activities giving rise to greenhouse gas emissions are deeply integrated in economic structures, and are widespread throughout the economy. For this reason, the costs of achieving targets for the reduction of greenhouse gas emissions are likely to be greater than the costs of meeting targets for the phase-out of ozone-depleting substances, for example.

There is undoubtedly some scope for reducing emissions without incurring major economic costs, and some reductions can result in economic benefits. Canadian efforts to reduce emissions can increase production efficiency, make our firms more competitive on world markets, and help promote the development of a Canadian environmental service industry which would be well placed to take advantage of overseas opportunities.

It must be recognized, however, that some measures being examined as having potential to reduce emissions could affect the competitiveness of Canadian businesses, particularly if Canada's major trading partners, including the United States, do not undertake similar actions. For this reason, policies or programs to reduce emissions must be developed through consultation with all interested parties, and must be sensitive to the policies and programs of our major trading partners.

The implications of a major reduction in greenhouse gas emissions, therefore, are considerably more complicated than those of reducing the use of ozone-depleting substances, for example. For the same reason, it will not be easy to enlist the cooperation of developing countries - their "historical contribution" to anthropogenic concentrations of greenhouse gases is relatively small, they currently account for a relatively small proportion of world greenhouse gas emissions, and they do not want to see their prospects for economic growth restricted by an international agreement limiting emissions. As illustrated in Figure 3, however, they account for the largest growth in projected CO_2 emissions (largely due to the relatively high rate of population growth in these countries) and therefore it will be critical to negotiate their cooperation.

Figure 3
PROJECTED GLOBAL ENERGY CO_2 EMISSIONS



Source: IPCC, EIS Subgroup

The IPCC is playing a central role in the process for a concerted international response to the issue of climate change. The IPCC was established to provide a framework for international collaboration on global warming. It set up three working groups to develop an international consensus on, respectively, the science, the impacts, and potential response strategies with respect to climate change.

Despite the difficulties in developing an international consensus on the issue of global warming, substantial progress has been made in a relatively short time. The 1988 Toronto Conference on the Changing Atmosphere was the first major conference at which policy makers and scientists came together to consider the implications of human activity on the atmosphere. Subsequent international meetings led to an acceleration of efforts to achieve a timely and substantive response to the problem of global warming.

In February, 1989, Canada and 23 other countries signed the Hague Declaration, which recognized the need for a global convention on climate change. A subsequent meeting in November, 1989, of Ministers from 76 countries at Noordwijk, also in the Netherlands, emphasized the importance of establishing quantified targets and schedules to limit or reduce emissions of greenhouse gases - it was recognized by Ministers that there was a need to stabilize atmospheric concentrations of greenhouse gases, while ensuring stable development of the world economy. In May 1990, the Regional Conference of 34 countries of the United Nations Economic Commission for Europe (ECE), including Canada, met in Bergen. All countries agreed at Bergen to commit to establish national strategies and/or targets and schedules, no later than the start of the negotiations of a framework convention on climate change, to limit or reduce CO_2 emissions and other greenhouse gas emissions as much as possible and to stabilize them.

More recently, the Second World Climate Conference, attended by Ministers and other representatives from 137 countries and from the European Communities, was held in Geneva from October 29 to November 7. This meeting provided opportunities for scientific as well as ministerial review of an interim report by the IPCC.

The scientific and technical session at the Second World Climate Conference reached a clear consensus on the range of global warming, and reaffirmed the IPCC's predictions of global warming and sea-level rise. The session noted the need to improve climate data, analyses, and, eventually, climate predictions. It also noted the inadequacy of climate observation/monitoring and climate change detection systems, and the need for greater efforts to understand the impacts of climate change including adaptation.

Ministerial representatives reaffirmed that, "in order to reduce uncertainties, to increase our ability to predict climate and climate change on a global and regional basis, including early identification of as yet unknown climate-related issues, and to design sound response strategies, there is a need to strengthen national, regional and international research activities in climate, climate change and sea level rise". The Ministerial session also maintained that "there is a need to intensify research on the social and economic implications of climate change and response strategies". At the same time, it was recognized that "Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing cost-effective measures to prevent such environmental degradation", and that "The potentially serious consequences of climate change ... give sufficient reasons to begin by adopting response strategies even in the face of significant uncertainties".

Ministers and other representatives agreed "that the ultimate global objective should be to stabilize greenhouse gas concentrations at a level that would prevent dangerous anthropogenic interference with climate". They stressed, "as a first step, the need to stabilize, while ensuring sustainable development of the world economy, emissions of greenhouse gases not controlled by the Montreal Protocol". Ministers welcomed the commitments by Canada and other countries "to take actions aimed at stabilizing their emissions of CO_2, or CO_2 and other greenhouse gases not controlled by the Montreal Protocol, by the year 2000 in general at 1990 level". Canada, as explained below, has already pledged to eliminate CFCs - one of the groups of substances controlled by the Montreal Protocol - by 1997.

The Ministerial session also urged developed countries, before the 1992 U.N. Conference on Environment and Development, "to analyze the feasibility of and options for ... a staged approach for achieving reductions of all greenhouse gas emissions not controlled by the Montreal Protocol" over the next two decades and beyond. It also recommended that "adequate and additional financial resources should be mobilized and best available environmentally sound technologies transferred expeditiously on a fair and most favourable basis" to enable developing countries to address climate change.

Preparations for the negotiation of a Framework Convention on Climate Change commenced in September under the auspices of the WMO and UNEP. Negotiations are expected to commence in February in the United States. Such a convention will seek an umbrella agreement among nations of the world to reduce human-induced climate change, and will be accompanied, either simultaneously or through subsequent agreements, by protocols with binding commitments to specific actions to achieve the objectives of the convention. A convention could be ready for signature at the 1992 U.N. Conference on Environment and Development. An important aspect of the convention will be the

issue of technological and financial assistance to developing countries.

Progress is also being made internationally on reducing greenhouse gas emissions in the context of negotiations whose immediate focus is a different environmental problem. An international conference was recently held in London to accelerate and expand international obligations under the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer. The conference agreed to accelerate the phase-out of five types of CFCs already controlled under the Protocol from a 50 per cent cut to a 100 per cent phase-out by the year 2000. Thirteen countries including Canada issued a separate declaration of their determination to take all appropriate measures to phase out CFCs as soon as possible but no later than 1997. Hydrochlorofluorocarbons (HCFCs), the principal substitutes for CFCs, is also a group of greenhouse gases. The Protocol calls for the phase out of these gases by 2020 or 2040. The conference also established a US$240 million fund to assist developing countries to adhere to the strengthened Protocol.

International cooperation to address emissions of nitrogen oxides (NO_x) and volatile organic compounds (VOCs) will also help to address the problem of global warming. These gases react in sunlight to form tropospheric ozone, a greenhouse gas. The NO_x Protocol, signed in 1988, committed Canada and 24 other countries to a freeze in NO_x emissions at 1987 levels. Negotiations are underway for a similar protocol to control VOC emissions. Canada's ongoing negotiations with the United States on an air quality accord will also incorporate commitments on controlling ozone and its precursors.

CHAPTER 4: THE DOMESTIC CHALLENGE

As indicated above, data on emissions of the principal greenhouse gases other than carbon dioxide are less reliable than for carbon dioxide. This is particularly true with respect to projections of future emissions. Such projections, of course, are essential to understanding the nature of the challenge posed by emission reduction targets.

Carbon dioxide

Energy-related emissions account for about 97 per cent of total known man-made CO_2 emissions in Canada (excluding emissions from agriculture). Energy-related emissions are a function of the level of energy demand and the contribution of the different energy sources to meeting that demand. Energy demand, in turn, is largely determined by the price of energy, the level of activity in the economy, technological developments, and public policy.

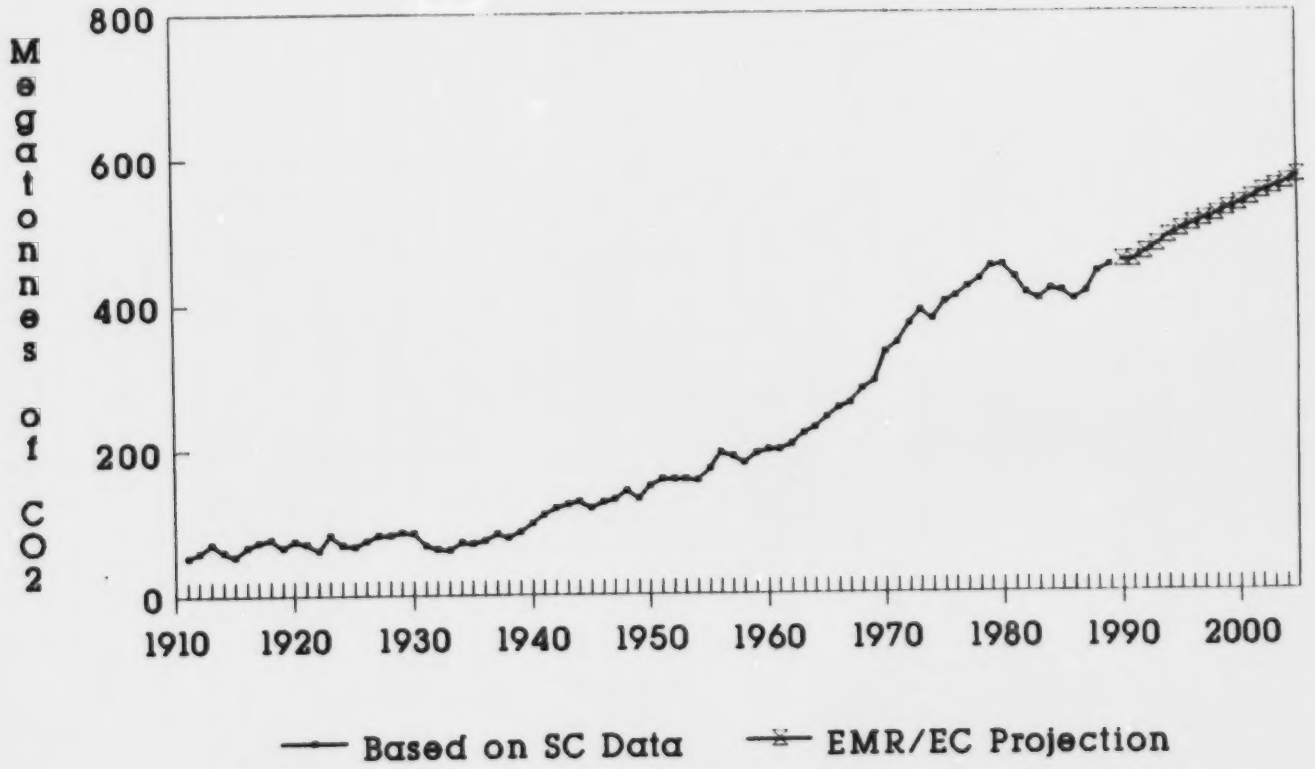
The projected path of energy-related CO_2 emissions over the next 15 years under "Business as Usual" assumptions, and actual emissions over the last 80 years, are shown in Figure 4. (These data do not include emissions from the combustion of biomass.) Emissions are expected to increase at an average annual rate of 1.6 per cent over the 1990-2000 period, so that emissions in 2000 are projected to be 17 per cent above their 1990 level. The principal driving force behind the projected increase in emissions is the expected growth in GDP.

The projected path of energy-related CO_2 emissions is roughly consistent with the historical path. The projected growth rate is somewhat less than that experienced over the last period of sustained growth, from roughly 1940 to 1980 - this is primarily due to a lower expected rate of population growth and therefore economic growth. Figure 4 indicates that CO_2 emissions have in fact increased steadily for most of the last 80 years. The most significant break in the trend occurred in the early 1980s, when emissions fell. While emissions began to increase again in the mid 1980s, by 1988 emissions were still only at about the same level as in 1979 and 1980.

There are a number of reasons for this dip in emissions: the OPEC oil price shocks of 1973/4, and, in particular, 1979; the fact that Canadian consumers were increasingly being exposed to world oil prices; government energy conservation and oil substitution programs; the fact that equipment manufacturers, in particular the automobile manufacturers, were adjusting to the oil price increases by producing equipment that was considerablymore fuel efficient than previously; and the recession that hit most western countries in this period.

Figure 4

ENERGY CO_2 EMISSIONS IN CANADA



*Excludes Biomass

The assumptions underlying any projection are always subject to debate (the assumptions and methodology behind the projection in Figure 4 are discussed in Annex 2). Nevertheless, the message of Figure 4 is clear: in the absence of a commitment by all Canadians to greater energy efficiency and conservation, a sustained oil price increase, or a recession, it is most unlikely that stabilization of CO_2 emissions at 1990 levels in 2000 will be achieved.

Other greenhouse gases

Emission projections are not available for methane from non-energy sources and for nitrous oxide. Work is proceeding to develop these data, both domestically and internationally. In the case of both gases, however, emissions are expected to be significant and to increase over time as economic activity and population increases, unless action is taken to reduce emissions.

In the case of CFCs, measures are being put in place to implement Canada's obligations under the original Montreal Protocol, which calls for a 50 per cent cut in consumption by 2000 relative to 1986. The Montreal Protocol, and the measures Canada is developing to implement a more rapid phase-out in consumption, are discussed more fully in a subsequent section. Also important is the recovery over time of the existing stock of CFCs currently in use, and the identification of an approach to achieve this.

Projections have been made of emissions of nitrogen oxides and volatile organic compounds, precursors of ground-level ozone. Under "Business as Usual" assumptions, both NO_x and VOC emissions in 2005 are projected to be about 6 per cent above their 1985 levels. However, under the 1988 NO_x Protocol, Canada is committed to a freeze in NO_x emissions at 1987 levels. The federal and provincial governments are currently developing a management plan to reduce NO_x and VOC emissions. (See Annex 4 for further details.)

CHAPTER 5: FRAMEWORK FOR RESPONSE

It is proposed that Canada's national action strategy on global warming have three key components: limitation, adaptation, and improving scientific understanding. It is also proposed that implementation of the plans of action that emerge from the strategy be managed through federal/provincial agreements.

Limitation

While scientific uncertainties about global warming remain, there is a general consensus internationally that the risks associated with inaction on greenhouse gas emissions are too great to wait upon the results of further research before commencing first actions. The limitation of emissions must begin now.

Adaptation

It makes sense to anticipate and prepare for potential climatic changes which Canada may experience as a result of global warming. The development of appropriate policies requires an understanding of current climates and how they are changing, and of the socio-economic implications of these changes.

Improving scientific understanding

Although there is a general consensus among a significant portion of the scientific community that global warming will occur as a result of changes in the composition of the atmosphere, and that it will have serious consequences, there are still many uncertainties. These uncertainties include the magnitude, rate and regional distribution of climate change. International research programs have been established to address these uncertainties. It is proposed that Canada play its part in these programs.

Management aspects

The specific plans of action which the federal, provincial and territorial governments will implement based on this strategy will be complex and interdependent (i.e., the success of some provincial initiatives will depend on the nature, scope and timing of actions the federal government takes and vice versa). This means that there must be close cooperation and coordination between governments. It is therefore proposed that the implementation of federal and provincial plans of action in component areas of the national action strategy be

institutionalized through the development of federal/provincial agreements. These agreements should provide the means for codifying

- the specific actions the governments will be taking
- the process that will be used to manage coordination, cooperation and reporting
- the means and schedules by which the parties will publicly report on progress, and
- the manner in which specific obligations in the agreements can be amended.

While it is recommended that a single agreement be negotiated between the federal government and each of the provinces, consideration will have to be given to the breadth of agencies and departments which should be involved in the process.

CHAPTER 6: LIMITATION STRATEGY

6.1 PRINCIPLES

It is proposed that Canada's limitation strategy on climate change be based on four fundamental principles. The first of these is that a comprehensive approach must be taken to reducing greenhouse gas emissions. The second is that any meaningful response to the problem must be taken in an international context. The third is that our response must be flexible. The fourth is that our response should recognize the importance of regional differences.

Comprehensive approach

The principle of a comprehensive approach means that a response to the problem of global warming must address all the major greenhouse gases, and must address sinks as well as sources. As noted in Chapter 2, the IPCC has identified the principal greenhouse gases as being carbon dioxide, methane, nitrous oxide and chlorofluorocarbons (CFCs). The IPCC noted that the contribution to greenhouse warming from tropospheric ozone may also be significant, but is difficult to quantify.

An effective response must also address the issue of sinks for greenhouse gases. Forests are, over their life cycle, neither a net greenhouse gas source nor a net sink. An aggressive program of reforestation, however, by increasing the size of Canada's natural carbon sink, can in the short term help to reduce net emissions of carbon dioxide. The time "bought" in this way can be valuable in facilitating the transition to an economy that is less dependent on fossil fuels. All other possibilities for capturing and utilizing or disposing of greenhouse gases should be considered, including the extraction of CO_2 from coal-fired power plants and its use in enhanced heavy oil recovery schemes or in carbon-based fertilizers, or its injection into the subsurface or the ocean for permanent storage. Possibilities for capturing methane from landfill sites and coal mines should also be considered.

Finally, a comprehensive approach must also take account of interactions with other atmospheric issues and pollutants. This would include the beneficial impacts of measures taken to reduce emissions of one pollutant on emissions of another, as well as the possibility that measures taken to address one environmental problem could be counter-productive in terms of another. The national action strategy recognizes the desirability of adopting a fully-integrated approach to dealing with atmospheric issues.

International context

The second principle recognizes that the problem of global warming is, by definition, a global one, and cannot be resolved by any one country or group of countries. It requires a concerted international response.

There are some measures that can be taken to reduce greenhouse gases which are judged to be desirable in their own right - it makes sense for countries to take such measures unilaterally. Other measures, however, could entail significant costs, or could confer an advantage on some countries while conferring a disadvantage on others. Before introducing such measures, countries must be assured that the burden is being shared, and that they will not be penalized in terms of international competitiveness.

A coordinated international approach also offers the greatest possibility of reaching a solution that is cost effective in a global sense. For example, it may be more cost effective to reduce emissions in developing countries which do not already employ state of the art technology. The international context is also important given that the future growth in greenhouse gas emissions is forecast to be the greatest in developing countries. Finally, the international context is important in ensuring consistency of greenhouse gas reduction targets with targets set by international agreements on other atmospheric issues.

The federal, provincial and territorial governments believe that all Canadians have a responsibility to take domestic action to respond to the problem of global warming. The action strategy recognizes, however, that Canada has a very open economy, and that it is highly dependent on international trade for its economic well-being. It is therefore important that measures taken to respond to the problem of global warming which could affect the economic competitiveness of Canadian businesses be coordinated with actions of our major trading partners to prevent major economic dislocations and a lessening of our ability to support environmental initiatives.

The national action strategy proposes that Canada continue to work actively in various fora to promote an international solution to the problem of global warming.

Flexibility

The principle of flexibility has a number of aspects. It recognizes that scientific and socio-economic understanding of the problem of global warming and its solutions are not yet complete - as our understanding improves, it may become clear that the problem is not as significant as currently believed, or that the level of effort currently contemplated as necessary to deal with the problem is inadequate. It also recognizes that

international consensus on addressing the problem has not yet been reached - measures which it would not be reasonable for a country to take unilaterally may make sense in the context of joint international action. It recognizes that we cannot be certain of the impact of the measures we take, either in terms of their success in reducing emissions of greenhouse gases, or in terms of their economic consequences. It recognizes that different jurisdictions in Canada may wish to address the problem in different ways, and focus their efforts on different areas. Finally, the principle of flexibility recognizes the importance of responding to the problem of global warming in a least cost manner.

All of these factors indicate that an appropriate response strategy would be one that is phased and progressive, giving us the flexibility to respond over time to new information and developments, and that it should allow us to select from a range of options and instruments. In terms of emission reduction, it should allow a choice among alternative approaches, such as one based on augmenting sinks, or seeking international opportunities for emission reduction, or selecting initiatives on the basis of a cost-benefit calculation. It is also for consideration whether an appropriate response strategy could also allow flexibility between limitation and adaptation strategies.

Regional differences

The principle that a limitation strategy should recognize the importance of regional differences is essential in the case of a country as large and regionally diverse as Canada. This principle has three primary aspects. It recognizes that while the federal government may introduce measures to reduce greenhouse gas emissions which have broad applicability across Canada, these measures will of necessity not reflect regional conditions. It will be necessary for the provinces and territories to introduce measures which are region-specific. For this reason, the set of limitation initiatives introduced will likely vary from jurisdiction to jurisdiction.

This principle also recognizes that the impact of national measures that are introduced will not necessarily be the same in all regions. Certain regions, for example, have fewer options in terms of energy supply than other regions. It is important, therefore, that in examining possible national measures, the specific characteristics of regional economies be taken into account, and that any national measures introduced be fair and equitable across regions.

Finally, this principle recognizes that regional characteristics should as far as possible be taken into account in the implementation of national programs.

6.2 ELEMENTS

6.2.1 Consultations

For a strategy to limit greenhouse gas emissions to succeed it must be truly national, meaning that all levels of government and all levels of society must be committed to it. For this to happen, there must be widespread consultation on its elements. The national action strategy therefore proposes that Canada's greenhouse gas limitation measures be developed and implemented in the framework of consultations with all levels of Canadian society. The role of consultations in various aspects of the limitation strategy are highlighted below.

6.2.2 International convention and protocols

Canada is actively supporting efforts to achieve a coordinated international approach to global climate change. In 1988, Canada hosted the first major conference at which policy makers and scientists came together to consider the implications of human activity on the atmosphere. The Toronto Conference led policy makers worldwide to recognize the seriousness of the potential problem of climate change.

Canada has participated actively in subsequent international meetings. For example, Canada was a signatory to the Hague Declaration of March 1989, the Noordwijk Declaration of November 1989, and the Bergen Declaration of May 1990. Canada has also contributed significantly to the work of the IPCC.

Canada will continue its active support for efforts to achieve concerted international action on climate change. We are pressing for conclusion of a Convention on Climate Change, and if possible some implementing protocols, in time for signature at the 1992 U.N. Conference on Environment and Development. Canada will seek to ensure that any international agreement contain firm targets and schedules for reducing CO_2 and other greenhouse gas emissions, and that it provide nations the flexibility to achieve reductions in a least cost manner in a global sense. Canada will also work for agreement on global targets for reforestation, and will seek to ensure that the agreement makes provision for enhanced cooperation on international climate change science.

An international agreement can only be successful if it has widespread support. Canada will, therefore, encourage the widest possible participation of the world's countries in the negotiations. In particular, it will work to ensure that the special concerns of developing countries are met so that they can participate fully. As noted previously, at the Second World Climate Conference in Geneva, Canada and other participating countries recommended that adequate and additional financial resources should be mobilized and best available environmentally sound technologies transferred to developing countries to enable

them to meet incremental costs required to address climate change. Canada will also develop bilateral arrangements to encourage other countries to commit to international agreements.

The national action strategy proposes that Canada's activities in this area be carried out in the framework of consultation with the provinces and territories, and with other interested parties within Canada.

6.2.3 Targets and schedules

While scientific and economic uncertainties about global warming remain, there is a general consensus that the risks associated with inaction on greenhouse gas emissions are too great to wait upon the results of further research before commencing first actions. As noted above, this consensus led at the Second World Climate Confernece to the expression of the precautionary principle, which stated that uncertainty should not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

At the Second World Climate Conference, Canada and 136 other countries and the European Communities stressed that the first step that must be taken is to stabilize emissions of greenhouse gases not controlled by the Montreal Protocol (i.e., gases other than CFCs). Canada confirmed its commitment to this first step through a program to stabilize emissions of CO_2 and other greenhouse gases at 1990 levels by the year 2000. Canada has already pledged to eliminate controlled CFCs by 1997. Canada's commitment to stabilization is a national target and does not pertain to specific regions and sectors.

Even if all countries succeeded in stabilizing emissions of greenhouse gases, this would not resolve the problem of climate change. Concentrations of greenhouse gases in the atmosphere would continue to increase, and therefore the process of global warming would continue. The national action strategy proposes that commitments to further reductions in emissions of greenhouse gases should be made in the context of negotiations on a framework convention.

The federal government, the provinces and territories must work together if such goals are to be achieved. Targets must also be realistic and achievable. It is important, therefore, that consideration of commitments to further reductions in greenhouse gas emissions take place within a framework of meaningful consultation and cooperation between the federal government, the provinces and territories, and interested Canadians. Consideration of such commitments, for example the 20 per cent cut in CO_2 emissions called for by the 1988 Toronto Conference, should include an examination of their technical feasibility and their cost and trade implications.

Carbon dioxide

As indicated previously, there is still significant work needed on identifying existing emission levels of carbon dioxide. This work is ongoing. Emission projections are even more uncertain than data on existing emission levels. It should be noted that, at time of writing, data on 1990 emission levels are estimates.

Figure 5, which presents our current best estimates of Canada's total carbon dioxide emissions from 1990 to the year 2000, illustrates the task facing Canada if it is to achieve stabilization. The projection is the same as that shown in Figure 4, except that it includes the small amount of emissions from non-energy sources (excluding emissions from agriculture). Figure 5 indicates that we would have to reduce emissions in the year 2000 by about 80 megatonnes of CO_2, or about 15 per cent, in order to achieve stabilization.

Other greenhouse gases

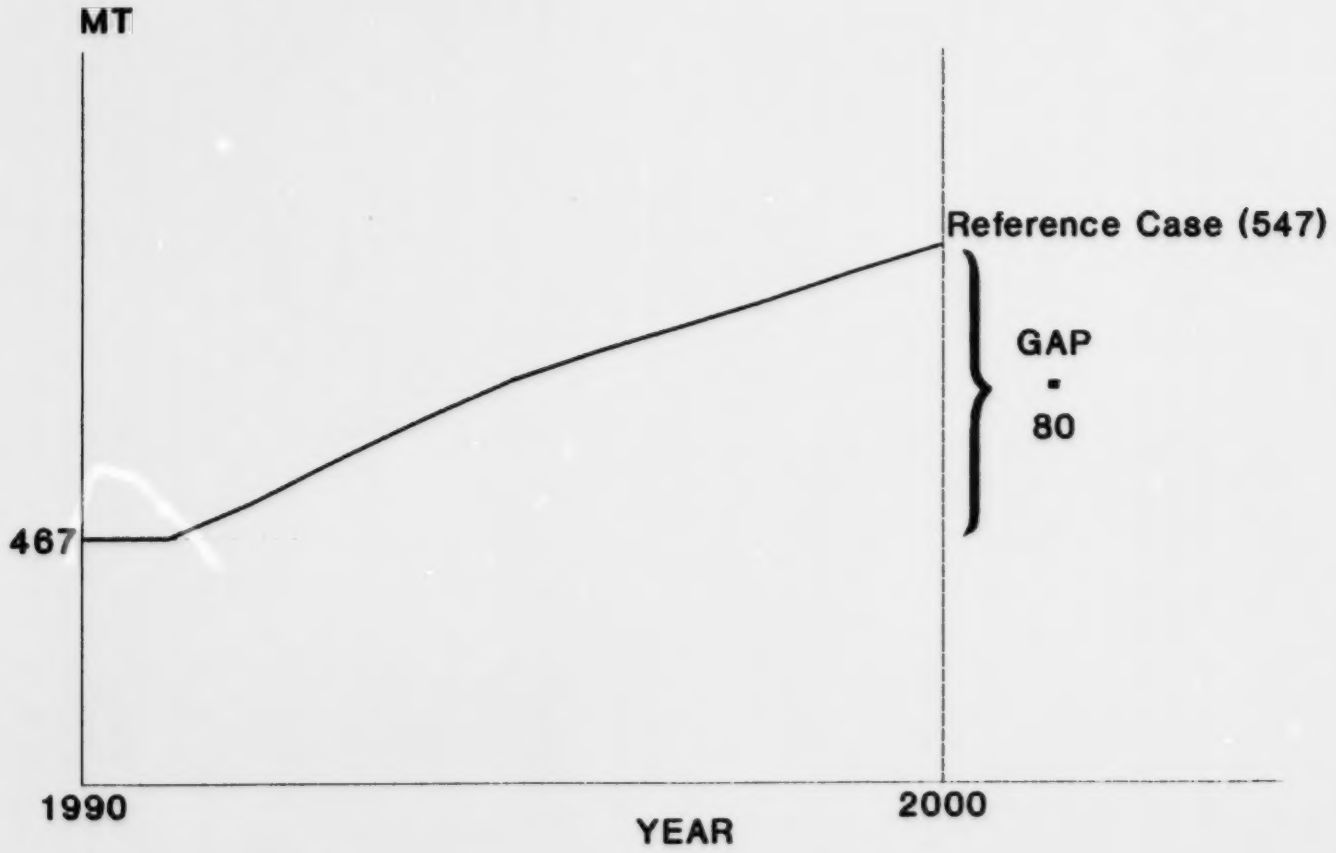
Data on emissions of methane and nitrous oxide are less reliable than they are for CO_2. While it is even more difficult to make reliable projections of emissions of these gases, it appears likely that emissions would increase over time in the absence of limitation measures. Stabilization, therefore, would be unlikely to occur in the absence of government initiatives to limit emissions. Stabilization is not a target in the case of CFCs and their interim substitutes (which also have a greenhouse effect), since Canada is committed to phasing out these gases.

6.2.4 Phased approach

The national action strategy proposes a phased, progressive approach towards limiting greenhouse gas emissions. This involves doing first those things which make sense in their own right, either because they are economic or because they also help to achieve other policy objectives, starting with those that have shorter lead times. Many of these first step measures are good for the Canadian economy and provide opportunities for Canadian business. The success of these first step measures in reducing emissions of greenhouse gases needs to be carefully monitored, and therefore appropriate monitoring mechanisms need to be developed.

It is recognized that changes in consumption, production and lifestyle patterns, particularly with respect to the way we use energy, that are more far-reaching and have longer lead times than those resulting from first step measures, may be required to bring us to stabilization or beyond. The national action strategy therefore proposes that processes be established for governments and stakeholders to commence immediate examination of these changes and of the more difficult measures that may be

Figure 5
STABILIZATION GAP - CO_2



Source: EMR/EC Projection

required to bring them about. The possible introduction of these measures will depend on the results of this examination, the success of the first step measures, developments in scientific understanding of climate change, and developments in reaching agreement on concerted international action.

The goal of the strategy is to put Canada in a position to respond quickly and appropriately to new information and developments as they occur over time.

CHAPTER 7: LIMITATION - FIRST STEPS

The following provides an overview of the sort of first step initiatives that are generally being contemplated to reduce greenhouse gas emissions. Individual jurisdictions may choose to consider an expanded or reduced list.

7.1 ENERGY - MEASURES

The consumption of fossil fuels is the primary source of Canada's CO_2 emissions, and is an important source of some other greenhouse gases. Annual CO_2 emissions can be limited by reducing overall energy demand and by switching to less carbon intensive energy sources. In the short term, there is limited scope for substitution away from fossil fuels in the energy mix. Moreover, non-fossil energy sources such as hydroelectricity or nuclear power have their own environmental impacts. The immediate emphasis, therefore, in terms of measures to reduce CO_2 emissions, must be on general energy efficiency improvements. There is considerable evidence that many of these efficiency improvements are economic in their own right.

Indeed, it is important for Canadian industry to seize all economically-viable opportunities to improve energy efficiency. This is helpful in maintaining Canadian competitiveness in the world marketplace over time. It is also important in the identification and development of new Canadian technologies and business opportunities. In short, improved energy efficiency is a challenge, but it is also an opportunity for Canada.

While many energy efficiency improvements already make sense in their own right, they will not occur because of market barriers to their adoption or individual decision-making. Innovative government action will likely be required to achieve significant levels of adoption.

Such action could take a number of forms, reflecting the fact that there is a variety of barriers to energy efficiency. Minimum energy efficiency standards remove the most energy inefficient products from the market. Information programs encourage people to use more energy efficient (or less environmentally damaging) products and, in some cases, encourage more energy efficient practices. Research, development and demonstrations assist in the development and marketing of new, more energy efficient and/or less carbon intensive technologies, and increase Canadian competitiveness and economic growth.

Different government jurisdictions could choose different sets of instruments, and target different sectors of activity. In deciding what measures to introduce, and the priority to be given them, governments should conduct analyses of the effectiveness of various measures in reducing energy consumption

relative to the cost of those measures, including the cost to governments. Cost-benefit analyses would also be useful in identifying those measures which are economic in their own right. In the case of national measures, such analyses should as far as possible seek to integrate regional cost-benefit analyses.

While governments have an important role in promoting energy efficiency and conservation, they cannot be effective acting alone. All elements of society share the responsibility of ensuring a rational and efficient use of our energy resources.

Energy efficiency improvements would reduce greenhouse gas emissions by reducing emissions of CO_2 and nitrous oxide, and by reducing the formation of tropospheric ozone (through reductions in emissions of NO_x and VOCs). They would also help to address other environmental and health problems. Local air quality would be improved by the reduction in NO_x and VOC emissions, while acid rain would be reduced by the reduction in sulphur dioxide emissions arising from coal combustion. (While energy efficiency improvements will generally lead to a reduction in all energy-related emissions, it is recognized that measures to reduce emissions of one pollutant can sometimes increase emissions of another.) Finally, energy efficiency improvements could postpone the need for new hydro-electric and nuclear generation facilities.

The federal government and some provinces already have active energy efficiency programs underway, but there is scope to make further inroads. It is recommended that the federal government, the provinces and territories introduce a series of further initiatives designed to promote energy efficiency and conservation where it is economic in its own right. Federal initiatives will be set out in full in the *Green Plan*. Active consultation processes are underway in a number of provinces to identify such further measures. Provincial and territorial initiatives will be announced as these consultation processes are completed.

7.2 ENERGY - CHALLENGE

Governments have identified a large number of areas where there is room for improvements in energy efficiency. While some of these areas can be addressed by the initiatives mentioned above, others will require key parties to change their behaviour in terms of energy consumption. It is therefore proposed to establish a process whereby energy users are challenged to work with governments and other stakeholders in identifying and evaluating new ways of becoming more energy efficient in order to help Canada achieve its CO_2 emission target. More specifically, the challenge process should

- set objectives and develop measures for improving energy efficiency/conservation in target sectors

- provide to the public detailed information on Canadian energy consumption by end use
- monitor progress in improving energy efficiency and conservation, and
- assess the need for new or revised government initiatives.

The process should be transparent and open. The federal government should coordinate action and report regularly to the public on the progress made in meeting energy efficiency objectives.

7.3 CFCs

Chlorofluorocarbons (CFCs) are best known as substances which deplete the ozone layer. CFCs, however, are also an important group of greenhouse gases, and therefore measures to reduce the consumption of CFCs play a dual environmental role.

Canada has played a key role in securing international agreement to phase out the consumption of CFCs. Our control program regulating the domestic phase-out of these gases is one of the most rigorous in the world.

Under the 1987 Montreal Protocol, Canada is committed to a 50 per cent reduction in consumption of five CFCs by 2000. Regulations implementing these obligations came into effect in July, 1989. Canada will achieve the first required 20 per cent reduction in CFC consumption almost two years before the 1993 date specified in the Protocol.

At the London Conference of June, 1990, the parties to the Montreal Protocol agreed to accelerate the phase-out of the five types of controlled CFCs to a 100 per cent phase-out by 2000. Canada and twelve other countries issued a separate declaration of their determination to eliminate CFCs no later than 1997. Regulations will be introduced to implement the more rigorous measures which will meet Canada's new phase-out goals.

Eliminating the production and importation of CFCs will not address the problem of the stock of existing CFCs, and the possible leakage of these gases into the atmosphere. The federal government recently announced that it is developing, in cooperation with the provinces, a national action plan for the recovery and recycling of CFCs.

One of the principal substitutes for CFCs is a group of gases known as hydrofluorocarbons (HCFCs). These gases are considerably less damaging to the ozone layer than CFCs, and can act as a very important bridge until ozone layer-benign substitutes are found. HCFCs, however, still cause some destruction to the ozone layer, and are also greenhouse gases. Under the Montreal Protocol, Canada is committed to phasing out

these gases no later than 2040, and if possible, no later than 2020. (See Annex 3 for further details.)

7.4 AGRICULTURE

Certain agricultural practices contribute to greenhouse gas emissions. Soil cultivation, for example, leads to loss of soil carbon, much of which is lost to the atmosphere as CO_2. Manure storage and disposal practices lead to emissions of methane, CO_2 and N_2O. The use of fertilizers leads to emissions of nitrous oxide, and can suppress the oxidation of methane to carbon dioxide.

It is proposed that the federal, provincial and territorial governments introduce programs to devise and encourage practices that will limit greenhouse gas emissions from agricultural lands and wastes, and that will make agricultural lands an effective sink for carbon. The initiatives should focus on research and development, demonstration and technology transfer components, and on-site studies. As well as reducing greenhouse gas emissions, the practices identified will help improve soil quality and the self-reliance of Canadian agriculture.

7.5 OTHER METHANE

Landfill sites are an important source of methane emissions. Canada has taken a major step towards reducing emissions from this source through its adoption of a national target of reducing waste generation by 50 per cent by the year 2000. It is proposed that further possible measures to reduce these emissions be examined. The examination could focus on, for example, reducing the amount of landfill by promoting the conversion of waste streams into energy or chemicals, and the capture of methane from the landfill sites and its combustion as an energy source, thereby displacing other forms of energy consumption. The examination could also focus on promoting the capture of methane from coal mines. The amount of methane leaked from natural gas transmission and distribution systems could also be investigated, and action to reduce leakages considered if warranted.

7.6 FORESTRY

It is recommended that governments take steps to increase the storage of carbon in forest sinks. While not a permanent solution to the problem of greenhouse gas concentrations, the fixing of carbon in trees leads to a temporary reduction in net CO_2 emissions, and therefore buys time for the development of a longer term response.

7.7 OZONE

Ozone is produced in the lower atmosphere by the reaction of nitrogen oxides (NO_x) and volatile organic compounds (VOCs). Because the chemical reactions depend on both sunlight and temperature, a sunny, hot summer, such as the summer of 1988, can produce extensive ground-level ozone - or smog - problems. Ozone in the lower atmosphere is also a greenhouse gas. However, while its contribution to radiative forcing is potentially significant, it is difficult to quantify.

Canada is developing a management plan to reduce the formation of ground-level ozone by reducing NO_x and VOC emissions. While the initiatives proposed in the plan are primarily motivated by the problem of urban smog, they will also help to reduce Canada's emissions of greenhouse gases. Some of the measures proposed include promoting the use of urban mass transit, the use of staggered work hours, and more effective speed limit enforcement. The draft management plan is being considered by CCME Ministers. (See Annex 4 for further details.)

7.8 INFORMATION

It is proposed that governments launch initiatives to educate and inform Canadians of the nature of the global warming problem, their role in the problem, and how they can help resolve it. A significant component of the initiative would address information, demonstration and technology transfer in the area of energy use and efficiency.

The information initiative should include an attempt to elicit a commitment from Canadians to deal with the issue of global warming, including possible changes in lifestyles. The initiative should be a joint federal/provincial/territorial effort, and should include the participation of industry and non-governmental organizations. Its focus could also be broadened to include all atmospheric issues.

CHAPTER 8: LIMITATION - BEYOND FIRST STEPS

8.1 IMPACT OF FIRST STEPS

8.1.1 Carbon dioxide

The first step measures outlined in Chapter 7 will lay the foundation for the limitation of CO_2 emissions. An Energy Challenge can build upon this foundation by identifying and encouraging additional actions to improve energy efficiency by all levels of government, by industry and by all individuals. In addition, technological developments may lead to energy demand and/or CO_2 emissions being less than currently projected. Ongoing monitoring, feedback and assessments will lead to a continuing adjustment and possible expansion of the first step measures to ensure that objectives are being met.

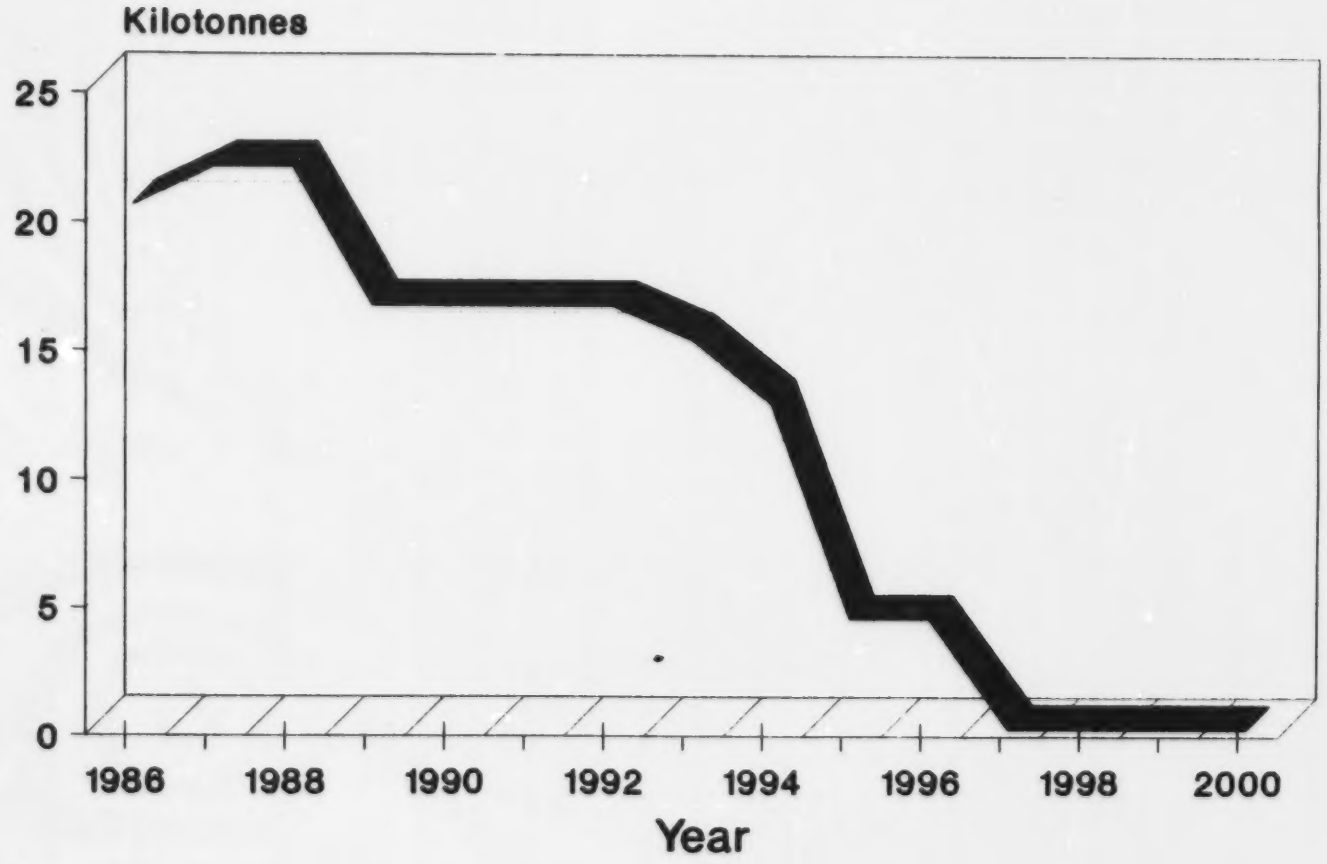
The above response, however, may not be enough to realize the full untapped economic potential for energy efficiency in the Canadian economy. It may become clear that more aggressive actions are required to realize the stabilization target. Or, Canada may consider adopting targets that are more ambitious than stabilization as the remaining scientific uncertainties surrounding the problem of global warming are better understood, and as an international consensus develops on the need for concerted action.

It is proposed, therefore, that governments commence examination of the more difficult and possibly more costly measures, and measures with longer lead times, that may be needed to bring about more far-reaching changes in the way that energy is used. A discussion of these measures is contained in section 8.2. The examination of these measures should include an assessment of the costs and benefits and social implications of the measures. In the case of national measures, such assessments should as far as possible seek to integrate regional analyses.

8.1.2 Other greenhouse gases

Stabilization is not, of course, an objective in the case of CFCs. As indicated in Figure 6, consistent with its international commitments, Canada will introduce the necessary measures to eliminate the consumption of CFCs in Canada by 1997. However, some CFCs will likely remain in place (e.g. in refrigerators), and consumption of HCFCs, which are also greenhouse gases, will likely increase as CFCs are phased out. HCFCs, however, are much less serious contributors to the greenhouse effect than are CFCs. Assuming total replacement of CFC consumption by HCFCs, and even with continuation of historic growth rates in consumption of fluorocarbons, it is estimated

Figure 6
CFC CONSUMPTION IN CANADA



Source: EC Projection

that the combined contribution of emissions of HCFCs and the remaining CFCs to global warming in 2000 would be less than 40 per cent that of 1990.

While the first phase measures outlined above are expected to have a meaningful impact on emissions of methane and nitrous oxide, it is not possible to give a quantitative estimate of this impact. The expected impact of the NO_x/VOC management plan is indicated in Figure 7. Phase I of the plan is expected to reduce Canada's NO_x and VOC emissions in 2005 to about 11 and 16 per cent respectively below 1985 emission levels. The Phase I measures alone, however, will not fully resolve Canada's ozone problem. Revisions to the plan will be made in 1994 (Phase II) and if necessary in 1997 (Phase III), defining additional reductions in NO_x and VOC emissions.

8.2 MEASURES

Certain measures to enhance energy efficiency, or to encourage the substitution of less carbon-intensive energy sources, are considerably more far-reaching in their implications than the first step measures outlined in Chapter 7. They may have implications for the lifestyle of Canadians or they could have important regional and economic impacts. Some measures could encourage actions where the costs of implementation significantly exceed the direct benefits from energy saved, and could only be contemplated in the context of joint and coordinated international action as negotiated over the coming years. It is proposed, therefore, that all of these measures be submitted to detailed consideration by the Canadian public. While we are not at the stage of implementing these measures, it is proposed that we begin examining them.

Some of the measures are under federal jurisdiction, while others are under provincial or municipal jurisdiction. Depending on the specific measure, therefore, the federal government or provincial governments should take the lead in coordinating the review. In most cases, however, it will be important that all the partners be involved in the review. Affected stakeholders should be involved in all cases.

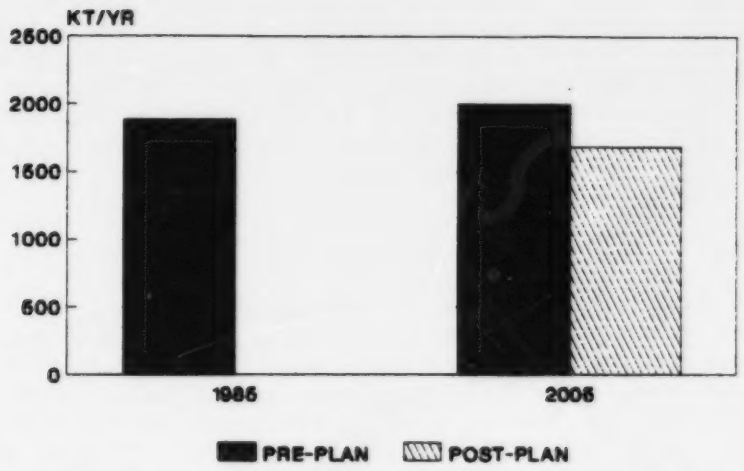
Ultimate introduction of the measures discussed below will depend on the results of the examination, the success of the first step measures, developments in scientific understanding of the scope of the global warming problem, and developments in reaching agreement on concerted international action.

8.2.1 Use of market forces

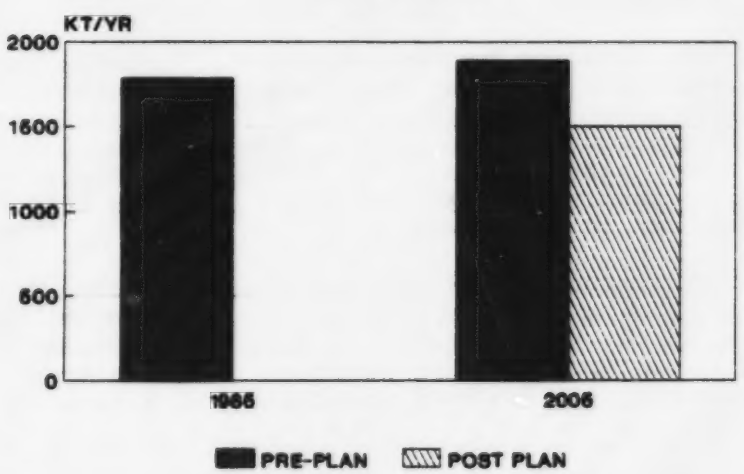
Market forces could be used to reduce CO_2 and other greenhouse gas emissions. For example, the tax system could be used to promote greater efficiency and conservation of energy use

Figure 7

PRE- AND POST-PLAN NO_x EMISSIONS



PRE- AND POST-PLAN VOCs EMISSIONS



Source: NOx/VOCs Management Plan

and, hence, reduce CO_2 emissions. Alternatively, a carbon emissions trading system could be introduced.

Preliminary evidence suggests that use of the tax system, in a manner that would be effective in reducing energy consumption, could have important economic, regional and lifestyle implications. Administration could also be complex. An emissions trading system could also have important economic implications, and would have a number of difficult design issues associated with it.

The national action strategy proposes that governments, in consultation with all interested Canadians and affected stakeholders, examine the possible use of market forces to address atmospheric problems, including global warming.

8.2.2 Utility incentive structures

Electricity accounts for about 24 per cent of end use demand for energy in Canada. About 22 per cent of electricity is generated from fossil fuels. Any attempt, therefore, to bring about a significant change in the way energy is used in Canada must address the electric utility sector.

Many provincial utilities - both gas and electrical utilities - have launched aggressive programs to encourage more efficient use of energy. The energy efficiency/conservation challenge process described in Chapter 7 would explore further potential in this area.

However, concerted action on CO_2 may require even stronger measures. One issue that needs to be addressed is that of electricity pricing, in particular the issues of marginal cost and peak load pricing, and declining block rate structures. Another issue is that of the incentives provided by electric and gas utility regulatory structures for activities to encourage more efficient electricity and gas use/conservation as compared to supply expansion. Issues that need to be addressed by electric utilities which are largely based on thermal power generation include alternative power generating technologies, and options for CO_2 utilization and/or disposal.

The national action strategy proposes that governments begin to examine the issues of electricity pricing and electric and gas utility regulatory structures.

8.2.3 Urban infrastructure

Changes in the way our cities function could play an important role in reducing carbon dioxide emissions arising from gasoline consumption. An increased use of urban mass transit and decreased use of private automobiles would lead directly to reduced fossil fuel consumption. An improved traffic flow and

reduced traffic density would lead to more efficient, and therefore reduced, gasoline consumption, even if there were no fewer cars on the road.

There are a number of measures that could be taken to encourage such changes in high population density areas. The use of urban mass transit could be promoted, and the use of private automobiles discouraged, by restricting access of private automobiles to city cores, raising downtown parking fees, and imposing urban highway tolls. The flow of urban traffic could be improved through better signal light coordination/computerization, the introduction of additional turn signals and lanes, and through greater use of one-way streets. Traffic density could be reduced through promoting staggered work hours and work at home.

Such measures, as well as involving economic costs, also imply changes in Canadians' lifestyles. They therefore require careful examination. Some of these measures are currently being examined in the context of the NO_x/VOC management plan.

The national action strategy proposes that the provinces, working with the municipalities, begin to examine the issue of possible changes in urban infrastructure to reduce carbon dioxide emissions.

8.2.4 Electricity generation options

As noted previously, there is little scope for substitution away from fossil fuels in the energy mix in the short term. This is particularly true in the case of electricity generation, in view of the long lead times involved in commissioning new facilities. If Canada is serious about more ambitious longer-term emission reduction targets, however, serious consideration may have to be given to increasing the contribution of non-fossil capacity in the electricity generation mix. Consideration may also have to be given to support for the development of technologies which increase the efficiency with which fossil fuels are converted to electricity.

Non-fossil options for electricity generation include nuclear, hydro, wind, solar, and tidal powered electricity. The use of biomass could also reduce net carbon dioxide emissions. Some of these options, such as hydroelectricity and nuclear power, have their own environmental impacts. It is important, therefore, that the environmental and health impacts of the various electricity generation options be carefully assessed.

Fossil fuels will likely continue to play a significant role in the generation mix in Canada and the world. The development of clean coal technologies and the more efficient use of all fossil fuels, through applications such as cogeneration, could substantially reduce greenhouse gas and other atmospheric

emissions in Canada and, if technology transfer occurs, elsewhere in the world.

The national action strategy proposes that the environmental and health impacts of electricity generation options be examined.

CHAPTER 9: ADAPTATION

It makes sense to anticipate and prepare for potential climatic changes which Canada may experience as a result of global warming. The development of appropriate policies to prepare for climatic changes requires an understanding of current climates and how they are changing, and of the socio-economic implications of these changes.

Impacts

The federal government established in 1978 a Canadian Climate Program to develop scientifically sound policies to address the issue of climate variability and change. A number of studies which assess and identify the potential social and economic impacts of climate warming have been funded under this program. These studies, which have focused on different regions of Canada, in conjunction with global studies, have provided a great deal of information on the possible implications of climate change for Canada. Some of the possible socio-economic implications of climate change for Canada that have been identified are, for example:

- There is a potential for northward migration of agriculture -- the extent of the migration would generally be limited by soil capability. An increase in pests and plant diseases would be likely. An increase in the frequency and severity of agricultural drought would also be likely, which could lead to increased demand for irrigation services.

- There is also a potential for a northward shift in forest ecosystems with, in some cases, narrower boundaries for some species. There would be a probable increase in forest damage from pests and fires, and a probable negative impact on winter logging operations due to warmer and wetter winters in northern areas.

- There could be an increase in ice-free shipping season in Canada's Arctic and the Great Lakes. There could, however, also be higher operating costs in the Great Lakes due to projected lower lake levels.

- Some communities and commercial properties would be at risk in coastal areas (for example, Vancouver, Charlottetown, Saint John). There could also be increased inland flooding, erosion of natural shorelines, and disruption of storm sewers and freshwater supplies.

It is important that research into the social and economic implications of global warming be continued.

The question of adaptation to the impacts of global warming that Canada may experience -- both to changes in average conditions and to the known variability of climate -- has not yet been systematically addressed. There is a need, for example, for research into the types of agricultural crops that would do best under different climatic conditions, and into the species of trees that would survive in different regions and the pests and diseases to which they would be susceptible.

Measures

It is proposed that the federal, provincial and territorial governments develop programs to assist adaptation to climate change. These programs should include the following components

- comprehensive monitoring of the environmental impact of global warming and fluctuations on Canada
- assessment of the corresponding socio-economic impact
- examination of government policies to determine the extent to which changes in these policies are required in light of the results of this monitoring and assessment
- informing Canadians about the impacts of global warming on Canada.

CHAPTER 10: IMPROVING SCIENTIFIC UNDERSTANDING

While there is a general consensus among scientists that global warming will occur, many uncertainties still remain. These uncertainties include the magnitude, timing, and regional distribution of climate change.

Areas of Research

The Canadian Climate Program Board has identified areas of research that Canada should support in order to improve scientific knowledge and predictive capability with respect to climate change. These include:

- integrated regional studies of the impacts of climate change
- collection, archiving and analysis of data over Canada
- climate system modelling
- significant participation in global research efforts to better understand and quantify the processes influencing the climate system, particularly as it affects Canada.

Integrated Regional Studies of Impacts

The Climate Board has identified a pressing need to pursue new directions in research on the impacts of climate change. One such direction is integrated, multi-sectoral analyses of selected regions -- the Mackenzie Basin, the Great Lakes Basin, and the Prairies/Great Plains. The Climate Board has indicated that these regional analyses should allow other economic, social and physical factors and feedbacks to be incorporated, and should consider response strategies.

Another direction in research identified by the Climate Board is sensitivity studies of the processes by which economic and social systems respond to environmental change. A better understanding of prospects for adaptation in economic activities would likely emerge from these studies.

A third identified direction in research on the impacts of climate change is the extension of the work based on climatic averages to studies of the effects of extreme events and of climatic variation between years (for example drought frequency, duration and degree) on economies and communities.

Data Collection, Archiving and Analysis

The Climate Board has indicated that Canada should improve and maintain an adequate basic data base over Canada, and that it should do so through both conventional observing networks and satellites. Earth observation from space provides a unique method to measure a number of atmospheric, ice and ocean parameters, vegetation cover, and land use across continents; satellite observations complement observation from surface-based stations.

Another component of a comprehensive data program identified by the Climate Board is reconstruction of past climates in order to address the problem of differentiating between natural variations in climate and the effects of human activity on present and future climate.

The Climate Board has also identified a need to facilitate access to digital data bases through standardized catalogues and directories.

Climate System Modelling

Canada has had initial success in the field of general climate models. The Canadian Climate Centre has developed one of the half-dozen world-class models in existence today. The model is one of only three "second generation" models. This state-of-the-art model has permitted scientists studying the potential social and economic impact of climate change in Canada to conduct their research with much finer-scale projections of future climate than models developed in other countries. This kind of climate system modelling is the main synthesizing tool for pulling together all of the information on climate, ice, snow, oceans, vegetation, and land cover to predict the consequences of changes in atmospheric composition and land use. The Climate Board has identified a need to build on Canada's initial success in the field of general climate models.

Participation in Global Research Efforts

Models which simulate the climate system depend not only on an adequate quantity of reliable data, but also on a quantitative understanding of the many processes and "feedback loops" that affect the climate system. Research on these processes is a main focus of the international Global Change Research Program with its twin pillars, the World Climate Research Program (WCRP) and the International Geosphere Biosphere Program (IGBP). Internationally, these umbrella programs are coordinated primarily by the World Meteorological Organization and the non-governmental International Council on Scientific Unions.

The Climate Board has indicated that Canada's contribution to global projects should be based on work to understand the

processes over the Canadian land mass and adjacent seas, and should be designed to help improve predictions of Canada's future climate.

Measures

Canada has been a world leader in research and modelling with respect to climate change, and it is proposed that Canada continue to play its part. It is recommended that the federal, provincial and territorial governments introduce initiatives to reduce scientific uncertainties in the area of global warming. The initiatives should focus on

- participation in international research programs
- developing and improving physically based models to simulate and predict the magnitude, timing and regional distribution of climate change
- improving and enhancing our regional and national data collection systems, and
- involving universities and the private sector.

In addition to the uncertainties discussed above, there are other uncertainties related to the role played by various human activities, such as agricultural practices, in greenhouse gas emissions. Further research and monitoring should be carried out with a view to providing better estimates of the impact of such practices on greenhouse gas emissions.

CHAPTER 11: CONCLUSION

Scientific and economic uncertainties about global warming remain. However, an international consensus has developed that the risks of inaction are so great that we must commence first actions.

Global warming is an international problem which requires an international solution, and Canada is working actively in various fora to promote an international solution. In the meantime, however, federal, provincial and territorial governments believe that all Canadians have a responsibility to take domestic action, while recognizing that taking certain actions out of step with other nations Canada would have little impact and could jeopardize its competitive position internationally.

Canada's proposed national response strategy has three elements: limitation, adaptation, and improving scientific understanding. With respect to limitation, the national action strategy proposes an approach that is comprehensive and flexible, and that recognizes the international context and regional differences. It notes the target confirmed by Canada at the Second World Climate Conference - to stabilize emissions of CO_2 and other greenhouse gases not controlled by the Montreal Protocol at 1990 levels by 2000 - and confirms Canada's commitment to meeting the target. The strategy also confirms that this is a national target and does not pertain to specific regions and sectors. The strategy proposes that commitments to further reductions in emissions of greenhouse gases be made in the context of negotiations on an international framework convention.

The action strategy proposes that a phased, progressive approach be taken with respect to reducing greenhouse emissions. It recommends that a set of first step measures be introduced which will lay the foundation for the stabilizaton of greenhouse gases. These first step measures are measures which help us achieve our goals, but would make economic sense in their own right and/or achieve other policy or social goals, and have shorter lead times. Many of them are good for the Canadian economy and provide opportunities for Canadian business.

While many of the activities promoted would be economic, measures are required to overcome market barriers to their adoption, and full consideration should be given to the costs of the measures to governments and other sectors. The action strategy proposes that, in deciding what measures to introduce and what priority to give them, governments should conduct analyses of the effectiveness of various measures in reducing energy consumption relative to the cost of those measures, including the cost to governments. Cost-benefit analyses would also be useful in identifying those measures which are economic in their own right.

More far-reaching changes in the way we use energy may be required to bring us to stabilization and beyond. The strategy proposes that we commence examination of the more difficult measures, and measures with longer lead times, that may be required.

The strategy recognizes the key importance of a consultative approach between the different levels of government and with all Canadians. Consultations must, in particular, play an important role in the consideration of commitments to further reductions in greenhouse gas emissions, and in the development and implementation of emission reduction measures. The strategy notes the importance of education in ensuring an informed and committed public. The strategy also recognizes that different jurisdictions will likely wish to give a different emphasis to the initiatives they introduce.

The strategy also proposes that measures be introduced to improve scientific understanding related to global warming, and to assist adaptation to potential climatic changes which Canada may experience as a result of global warming.

Overall, Canada's national action strategy proposes a process for continually monitoring developments, reducing uncertainty and putting Canada in a position to respond appropriately at every step of the way.

CANADA'S GREENHOUSE GAS EMISSIONS

CARBON DIOXIDE

Canada's relatively high rank in terms of energy-related CO_2 emissions is essentially the result of two factors. In the first place, Canada is one of the most energy intensive countries in the world. Figure A1 indicates that Canada ranks highest among the major, free market, industrialized countries in terms of both energy consumption per capita and energy consumption per unit of output. Partly offsetting this factor, however, is the fact that Canada's energy consumption is itself relatively low in terms of carbon intensity. This reflects the significant role that hydro and nuclear electricity play in meeting Canada's energy needs. (The International Energy Agency, which compiled the data presented in Figure A1, has recently revised its method of accounting for hydro and nuclear electricity - the revised methodology reduces Canada's energy consumption relative to other countries, though Canada's ranking as shown in Figure A1 is unchanged.)

The results in Figure A1 do not mean that Canada is wasteful in terms of its energy consumption - there are a number of reasons for our relatively high level of energy intensity. In the first place, the Canadian climate is harsher than that of many other countries. On average, Canada is about 40 per cent colder (in terms of heating degree days) than the United States, West Germany, France and Italy. As a result, more energy is used in Canada per household for space heating. Secondly, Canada's population is distributed over longer distances than in most countries. This leads to greater energy use per capita in the transportation sector.

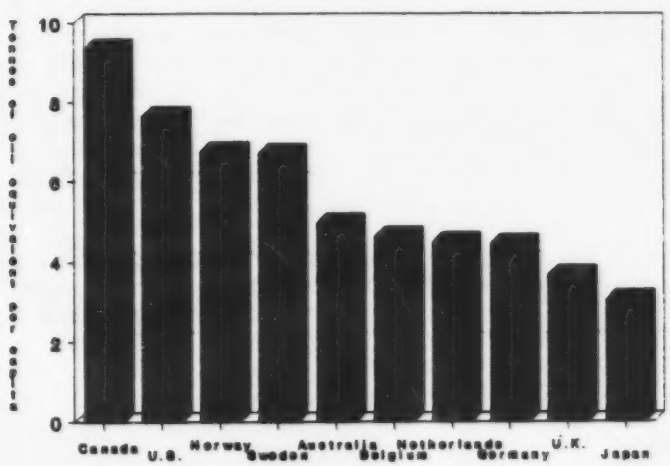
A third reason for Canada's high level of energy intensity relates to its resource endowment. Canada is fortunate to be endowed with substantial quantities of virtually every type of energy. Some of these types of energy, in particular coal and hydroelectric resources, have significant transportation costs or transmission losses associated with them. It can make economic sense to consume these energy sources in Canada rather than seek to export them. Moreover, Canada is in general a resource rich country, and resource extracting and processing industries tend to be energy intensive. It is therefore economic for Canada, and leads to an efficient use of the world's resources, for Canada to engage in industrial processes which are relatively energy intensive. Indeed, Canada's energy resource endowment has encouraged energy-intensive industries (such as aluminum smelting) to locate here.

Finally, some other countries, especially in Western Europe, tax energy much more heavily than does Canada. For this reason, the price of gasoline, for example, is considerably lower in Canada than in most European countries. This price differential

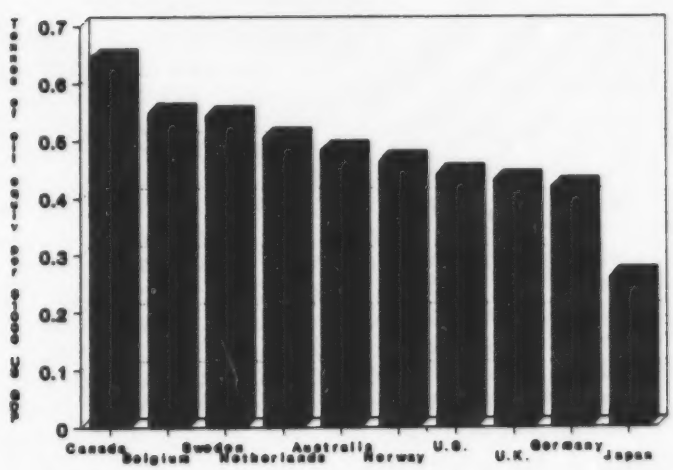
Figure A.1

INTERNATIONAL COMPARATIVE ENERGY INTENSITIES
PRIMARY ENERGY REQUIREMENTS - 1987

PER CAPITA



PER UNIT OF OUTPUT



Source: IEA

induces European drivers to be more conscious of their fuel consumption than are Canadian drivers.

Canada's non-energy sources of CO_2 emissions - primarily from cement and ammonia production - are relatively small, amounting to about 3 per cent of energy-related emissions. Agriculture may be a significant source of carbon dioxide emissions. Estimates of these emissions, both on a national and an international basis, are uncertain. Finally, deforestation is an important source of emissions in some countries. Canada's share of world emissions would be lower if emissions from this source were included with energy-related emissions in the world total.

OTHER GREENHOUSE GASES

Data on emissions of some of the other greenhouse gases are not as fully developed as they are for CO_2. In particular, projections of emissions are not available for methane and nitrous oxide. Work is proceeding to develop this data. Data on base year emissions are also uncertain. A preliminary estimate of base year emissions of these gases is 3800 kilotonnes of methane, and 108 kilotonnes of nitrous oxide. In terms of global warming potential, this is the equivalent of 80 and 31 megatonnes of CO_2, or about 19 and 8 per cent of energy-related emissions, respectively. An estimate of the relative contribution of different sources to base year emissions for these gases is shown in Tables A.1 and A.2, respectively.

In the case of methane, about 50 per cent of anthropogenic emissions come from landfill sites, while about 25 per cent come from large animals. In the absence of initiatives designed to reduce emissions, it appears likely that emissions will increase over time as economic activity increases.

In the case of nitrous oxide, about 25 per cent of emissions come from the use of fertilizer, about 20 per cent from nitric acid production, and about 55 per cent from fossil fuel combustion. Again, in the absence of initiatives addressing these particular sources, it appears likely that N_2O emissions will increase over time.

In the case of CFCs, emissions in 1987 were the equivalent of 112 megatonnes of CO_2, or about 27 per cent of energy CO_2 emissions. CFCs are principally used commercially in foam, refrigerants, air conditioners, aerosols and solvents. In the absence of measures to reduce CFC consumption, it is estimated that CFC emissions would increase by about 1.3 per cent per year, reaching the equivalent of 130 megatonnes of CO_2 in 2000. In fact, however, measures have been introduced to reduce CFC consumption, and further measures to phase out CFCs are being developed. (Further details on Canada's international commitments and domestic program with respect to CFCs may be found in Annex 3.)

TABLE A.1

ANTHROPOGENIC METHANE EMISSIONS IN CANADA

SOURCE	ESTIMATED % OF TOTAL
Coal mining	4
Fuel combustion	6
Natural gas leaks	7
Biomass	2
Landfill sites	49
Large animals	24
Manure	9
TOTAL	100

Source: Environment Canada

TABLE A.2

ANTHROPOGENIC NITROUS OXIDE EMISSIONS IN CANADA

SOURCE	ESTIMATED % OF TOTAL
Natural gas combustion	11
Oil combustion	20
Coal combustion	17
Wood combustion	7
Nitric acid production	19
Use of N-Fertilizers	26
TOTAL	100

Source: Environment Canada

BACKGROUND TO GREENHOUSE GAS PROJECTIONS

CARBON DIOXIDE

Methodology

The "base case" projection of carbon dioxide emissions shown in Figure 4 was prepared by Energy, Mines and Resources Canada (EMR) and by Environment Canada (EC). About 97 per cent of emissions are estimated to come from the combustion of fossil fuels, with the remainder coming from non-energy sources such as cement and ammonia production and incineration. The projection of energy-related emissions is based on an econometric model of energy demand developed by EMR. The non-energy emissions were projected separately.

Econometric models are a frequently used tool for forecasting aggregate energy demand. These models relate aggregate energy demand on the basis of historical relationships to a variety of variables that influence energy consumption, the most important being energy prices, economic growth, and demographic change. The EMR model first projects total energy demand for each of the residential, commercial and industrial sectors, and then breaks down this forecast into a forecast of demand for each fuel type. The projection of energy demand in the transportation sector is carried out on a more disaggregated basis. The projection of energy use in the non-energy sector is based on the production plans of the petrochemical sector. A utility generation model is used to determine how a given demand for electricity will be supplied, and what fuels will be used to generate electricity at the provincial level.

While the forecast is largely based on historical relationships, the model results are often modified to incorporate technological improvements not captured by historical data. In addition, the EMR/EC forecast was adjusted in the case of electricity to reflect the announced plans of electric utilities, and in the case of gasoline demand to reflect changes in the structure of the automobile market.

Assumptions

The EMR/EC forecast is based on a world oil price scenario in which the price of crude oil increases from $US 18/bbl in 1989 to $US 25/bbl (in 1989 dollars) by the year 2000. GDP is assumed to grow at an average rate of 2.4 per cent per annum. Population growth is assumed to be slightly below 1 per cent between 1990 and 2005.

Results

Carbon dioxide emissions are projected to grow at an average rate of 1.6 per cent over the 1990-2000 period, so that emissions in 2000 are about 17 per cent higher than in 1990.

The sectoral distribution of these emissions is shown in Figure A.2. Transportation is estimated to account for about 28 per cent of energy-related carbon dioxide emissions in 1990, and industry for about 18 per cent. About 23 per cent is estimated to result from the conversion of fossil fuels to electricity, about 18 per cent is produced by direct fossil fuel consumption in the residential and commercial sectors, and roughly 13 per cent is associated with producer and non-energy consumption ("other" in Figure A.2).

Over the coming ten years, most sectors are projected to have a roughly equal rate of growth in emissions, with the exception of the residential sector and the producer consumption and non-energy sector. The residential sector is projected to have virtually flat emissions over the period, largely due to a slow rate of population growth. The producer consumption and non-energy sector is projected to have the highest growth rate, largely due to emissions associated with natural gas production, which is expected to increase rapidly.

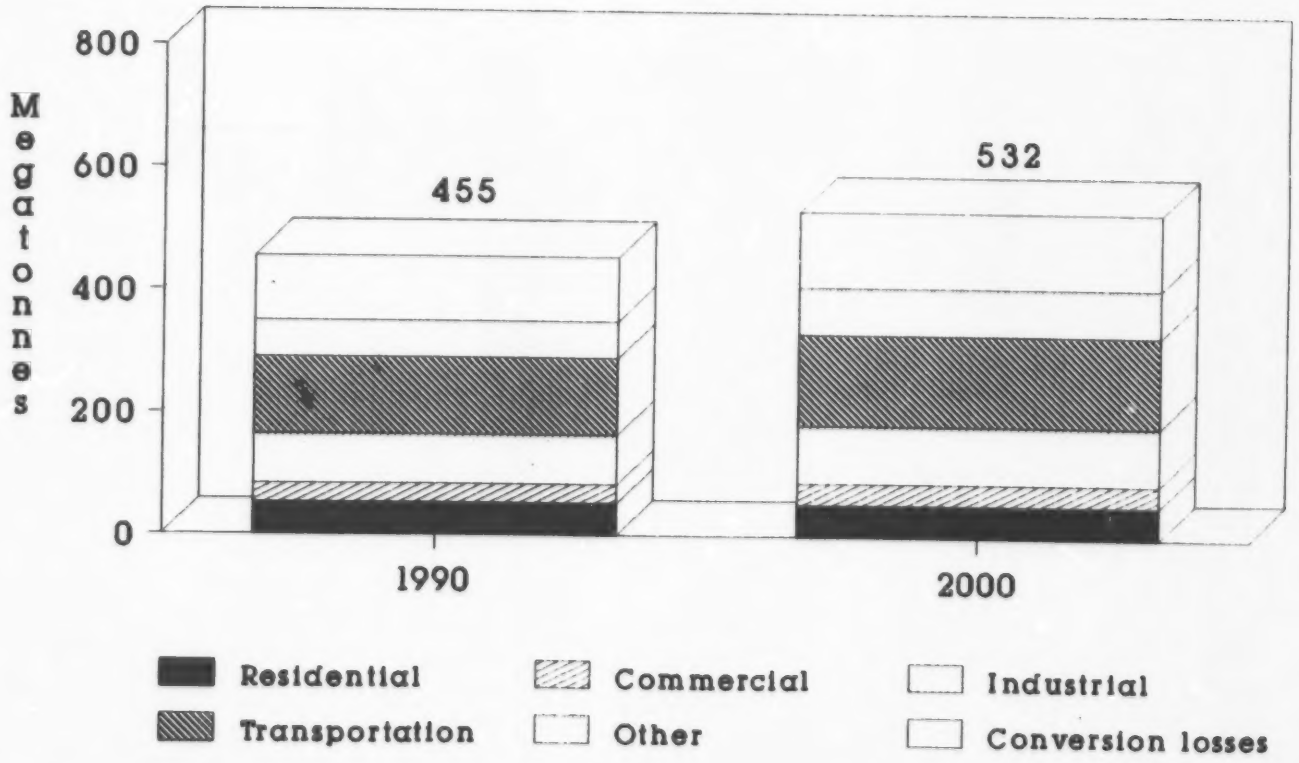
Figure A.3 shows the estimated distribution of CO_2 emissions by province for 1990, and the projected distribution for 2000. Ontario is the province which produces the most emissions, followed by Alberta. These are also the provinces which, over the coming ten years, are expected to display the most rapid growth in emissions. The high projected growth rate is largely the result of a projected increasing share of electricity in energy demand, and the importance of fossil fuels in electricity generation in the two provinces. The results in Figure A.3 are broadly similar to those of provincial ministries of energy.

Sensitivity analysis

The results of the EMR/EC projection are, of course, dependent on the underlying assumptions. Oil prices, in particular, are notoriously difficult to forecast accurately. At time of writing (October, 1990), oil prices are above the forecast level for 2000 as a result of the Gulf crisis. Higher crude oil prices would tend to reduce energy demand, and therefore lead to lower CO_2 emissions than currently forecast.

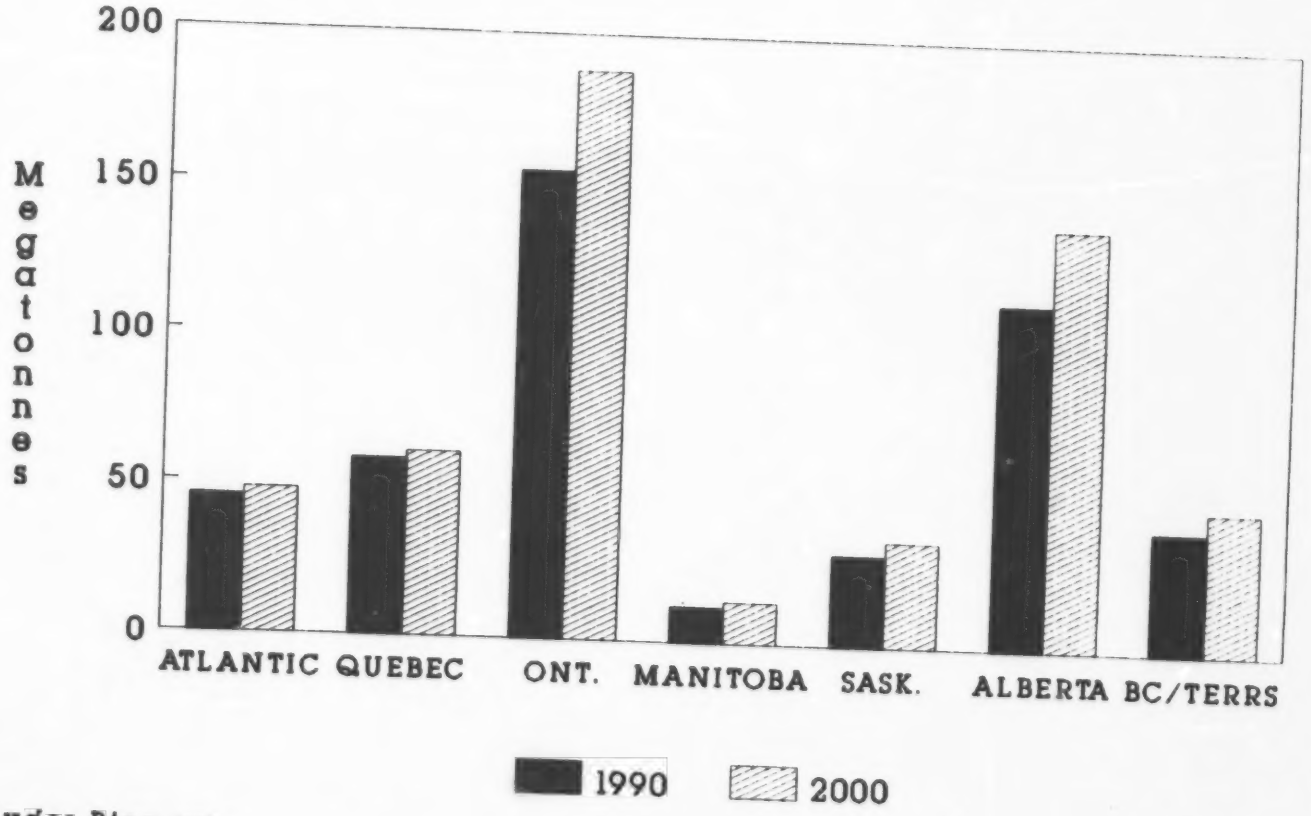
Most expert opinion is of the view that the current high level of oil prices is not sustainable over the longer term. It should also be noted that the effect of an increase in oil prices on reducing CO_2 emissions is much less than proportional. This is because the crude oil price represents a relatively small percentage of the price of petroleum products. A sensitivity analysis performed on the EMR/EC forecast indicates that if oil

Figure A.2
ENERGY CO_2 EMISSIONS BY SECTOR - TOTAL CANADA



*Excludes Biomass
Source: EMR/EC

Figure A.3
ENERGY CO_2 EMISSIONS BY PROVINCE



*Excludes Biomass
Source: EMR/EC

prices were $10 higher than forecast over the 1990-2000 period (a 40-56 per cent increase), and taking into account the macro-economic consequences, CO_2 emissions in 2000 would be reduced by only about 35 megatonnes (a 6 per cent reduction). The impact of higher oil prices on the stabilization "gap" of about 80 megatonnes, however, would be much more significant - it would be reduced by about 44 per cent.

OTHER GREENHOUSE GASES

As indicated previously, data on emissions of some of the other greenhouse gases are not as fully developed as they are for CO_2. In particular, emission projections are not available for methane and nitrous oxide. Preliminary estimates of base year emissions of these gases indicate that our emissions of methane are equivalent to about 18 per cent of our CO_2 emissions, while our emissions of nitrous oxide are equivalent to about 7 per cent.

About 50 per cent of anthropogenic emissions of methane come from landfill sites, while about 25 per cent come from large animals. About 25 per cent of anthropogenic emissions of nitrous oxide come from the use of fertilizer, about 20 per cent from nitric acid production, and about 55 per cent from fossil fuel combustion. In the case of each gas, emissions are likely to increase over time as economic activity increases, unless action is taken to reduce emissions.

Canada's CFC emissions are equivalent to about 27 per cent of our CO_2 emissions. CFCs are principally used commercially in foam, refrigerants, air conditioners, aerosols and solvents. Measures have been put in place to implement Canada's obligations under the original Montreal Protocol, which calls for a 50 per cent reduction in consumption by 2000. Measures are being developed to implement Canada's target of eliminating CFC consumption by 1997.

CFCS - INTERNATIONAL NEGOTIATIONS AND DOMESTIC PROGRAM

INTERNATIONAL NEGOTIATIONS

In 1985, following considerable scientific debate and international negotiations, the Vienna Convention on the Protection of the Ozone Layer was signed. The Convention established a framework to protect the earth's upper atmosphere through cooperative international efforts, mainly through scientific research and information exchange. Canada played a key role in the development of the Convention, and was the first country to formally ratify it.

The world's first global air pollution control program followed two years later - the Montreal Protocol on Substances that Deplete the Ozone Layer. The agreement was accomplished under the United Nations Environment Programme (UNEP), and marked the culmination of over five years of intensive international negotiations. Again, Canada played a key role in the development of the accord. In 1986, a Canadian Treaty framework proposal broke a serious deadlock and paved the way for the development of the final agreement. In recognition of Canada's leadership, UNEP accepted Canada's offer to act as the host country for the final signing of the Protocol.

The Montreal Protocol set out a schedule to control all substances that deplete the ozone layer. It called for an initial freeze in consumption of five CFCs, and a 50 per cent reduction in consumption by 2000. It recognized special terms for developing countries whose consumption was small, and put in place a science-based assessment and review process for future Protocol amendment.

Twenty-four countries initially signed the Protocol. Strong trade sanctions against non-participating countries were included in the agreement, which encouraged other countries to sign both the Protocol and the Convention. Signatories to the Montreal Protocol now number 59, plus the European Economic Community. Canada was one of the first countries to ratify the Protocol.

As evidence was gathered of more serious ozone depletion over polar regions, Canada worked actively to seek international agreement for a strengthened Montreal Protocol. Canada chaired the International Technology Panel, which defines what is currently technologically feasible, and the negotiations leading up to the London Conference in June, 1990.

In London, the parties to the Protocol amended and expanded it in both stringency and scope. Countries agreed to accelerate the phase-out of the five types of CFCs controlled under the Protocol from a 50 per cent reduction to a 100 per cent phase-out by 2000. Canada and twelve other countries issued a separate declaration of their determination to eliminate CFCs no later than 1997. It was also agreed that HCFCs - CFC substitutes which

are also greenhouse gases - would be confined to uses as substitutes and would be phased out by 2020-2040. Further control measures will be considered at the 1992 meeting of the parties.

One of the principal achievements of the London Conference was in securing the agreement of developing countries to the phase-out of CFCs. This was achieved in part through the industrialized countries pledging a fund of $240 million (US) to assist developing countries to meet the cost of the phase-out. Canada has committed about $10 million for the first three years of the fund.

Canada's offer to establish, in Montreal, the secretariat and information clearing house for the executive committee charged with administering the fund, has been accepted. This will result in an additional contribution of $5 million by Canada over the first three years of the fund.

DOMESTIC PROGRAM

Canada has in place domestic regulations, under the Canadian Environmental Protection Act (CEPA), to implement the Montreal Protocol's CFC control obligations. Draft regulations under CEPA were proposed in the spring of 1989. The final regulations came into effect in July, 1989.

The federal government recently announced its intention to ban the use of CFCs in automobile air conditioners and other products. The target dates for these bans, which go beyond the requirements of the amended Montreal Protocol, are

- 1993 for their use as blowing agents in flexible foams
- 1994 for their use as solvents for sensitive electronic equipment
- 1994 for their use as hospital sterilants
- 1995 for their use as blowing agents in poured and sprayed plastic foam insulation, and
- the 1995 model-year for use of CFCs in automobile air conditioners.

The government is preparing regulations aimed at achieving the 1997 phase-out. In addition, it plans new regulations to ensure that the 19 per cent reduction in CFC use already achieved in Canada is taken as a starting point for the more stringent reductions agreed to in London. Further measures to help Canada achieve its goal are being pursued with the provinces.

Annex 4

OZONE AND ITS PRECURSORS

At the international level, Canada signed the NO_x Protocol in 1988, committing it to a freeze in NO_x emissions at 1987 levels, to the application of best available technology economically achievable to new sources, and to the establishment of further measures to solve NO_x-related environmental problems by 1996. Canada is now participating in the negotiation of a VOC protocol. In addition, efforts are being made to establish a transboundary air quality agreement with the United States which would focus first on sulphur dioxide, but under which ozone, NO_x and VOCs could eventually be included.

Domestically, Canada is developing a management plan to reduce NO_x and VOC emissions. The federal and provincial governments are expected to conclude an agreement on Phase I of the plan by 1992. The management plan includes a range of initiatives to reduce emissions in all sectors.

These initiatives are fully set out in the draft management plan, currently under consideration by CCME, and therefore will not be reviewed in detail here. The measures are to be put in place for the most part over the 1991-94 period. They will affect numerous mobile and stationary source sectors that emit NO_x and/or VOCs, ranging from automobiles to power plants to refineries to solvent use categories such as paints and coatings. They will also affect lifestyle to some degree through the influence of product choice, consumer habits and transportation modes. One measure that has already been announced is the requirement for "California" emission standards for 1994 model-year cars.